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Technical Review and Development of Preliminary Capital and Operating Cost Estimate Comparison of Asbestos Wet and Dry Milling Processes

Kilborn et Associés Ltée

TECHNICAL REVIEW AND DEVELOPMENT OF PRELIMINARY CAPITAL AND OPERATING COST ESTIMATE COMPARISON OF ASBESTOS WET AND DRY MILLING PROCESSES

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- Details of Capital Cost Estimate

1.0 EXECUTIVE SUMMARY

Kilborn et Associés Ltée was requested to carry out a technical review and to develop a preliminary capital and operating cost estimate comparison of asbestos wet and dry milling processes.

The study is based on a plant rated at a production of 30,000 metric tonnes of fibre per year, which was judged to be a break-even point for a dry processing plant. The mill feed is dry mill tailings with a content of 5% recoverable fibre and a moisture content of 6%. The wet process flowsheet was supplied by the Scientific Authority of Canmet and is based on ORF laboratory and industrial pilot plant test work. The dry process flowsheet was supplied by Kilborn and based on their experience in dry milling of asbestos. Care was taken throughout the study to be fair and equitable to both methods.

Due to the fact that the flowsheet was based on test work carried out on laboratory scale equipment and other preliminary data, Kilborn had to make various scale-up assumptions for the study. These assumptions will have to be verified through further research.

Process Flowsheets

The dry process flowsheet of the tailings feed follows standard dry milling techniques of screening and airlifting with only one stage of impact crushing (for spicule development). Fibre cleaning and fibre opening is done with standard screening, fibre opening and fibre dedusting equipment. Fibre is produced at 1% moisture.

The wet process flowsheet contains two stages of fibre recovery (in elutriation cones) and three stages of fibre cleaning, i.e. two stages of washing trommels and one stage of gravity tables. Fibre product and fine tailings are dewatered in filter presses. The fibre product is dried to 10% moisture.

Capital Cost

Order of magnitude capital costs for the two process plants were calculated and are as follows:

Dry mill	$19.1 million
Wet mill	$13.8 million

The normal contingency of 10% for the dry mill is increased to 25% for the wet process mill, to reflect the more conceptual nature of the design.

Operating Cost

Order of magnitude operating costs of the two plants were estimated as:

Dry mill	$11.0 million
Wet mill	$ 8.7 million

It can be concluded that for the wet mill:

1. Labour cost is lower due to a smaller labour force.

2. Maintenance cost is lower because of reduced equipment requirements.

3. Power cost is lower because of reduced connected horsepower.

4. Drying cost is lower.

Revenue

Revenue has been based on the FSU (fibre strength test) adjusted for the moisture content and the 1985 asbestos price list, discounted by 25% to reflect current market conditions.

Dry mill fibre production is assumed to test as 5R (85 FSU) and 6D (75 FSU), while preliminary tests show that the wet mill fibre production can be classified as 4T (110 FSU) and 5R (85 FSU).

The annual revenue is summarized as follows:

Dry mill	$13.2 million
Wet mill	$18.3 million

An order of magnitude economic evaluation was carried out assuming a 10 year production period, no inflation and a combined federal and British Columbia provincial income tax of 53.5%.

The ROI of the two concepts is summarized as follows:

Dry mill	0.0%
Wet mill	47.0%

Conclusions

It should be mentioned that the order of magnitude calculations are based on several scale-up assumptions, nevertheless the study has shown that:

a) A dry plant for tailings producing about 30,000 mt of fibre per year, based on 5% recoverable 5R and 6D asbestos fibres, is approximately a break-even project.

b) A wet plant for tailings, based on 5% recoverable 4T and 5R (lower -200 mesh) asbestos fibres, is an economic viable project, if the assumptions can be confirmed.

c) Additional research with large scale equipment is justified.

1.0 SOMMAIRE

Kilborn et Associés Ltée a été mandaté pour préparer une étude technique et pour estimer le coût d'investissement et les coûts d'exploitation, pour fin de comparaison entre une usine de traitement humide et de traitement à sec de l'amiante.

Pour cette étude on a pris comme base une usine produisant 30,000 tonnes métriques de fibre d'amiante par année, ce qui était considéré représenter le seuil de rentabilité d'une usine de traitement à sec. L'alimentation provient des rejets d'une usine de traitement à sec, contenant environ 5% de fibre récupérable et 6% d'humidité. Le schéma du procédé de traitement humide a été fournit par les autorités scientifiques de Canmet. Ce schéma avait été établi d'après les études exécutées au laboratoire de l'ORF et d'après des essais en usine pilote. Le schéma de traitement à sec a été préparé par Kilborn et est basé sur l'expérience pratique. Au cours de cette étude, nous avons essayé d'être juste et équitable envers les deux procédés de traitement.

Parce que le schéma de traitement humide fut préparé d'études exécutées en laboratoire, ayant utilisé de l'équipement miniature et que les résultats ne sont que préliminaires, plusieurs hypothèses ont été élaboréés pour faire la conception de l'usine à traitement humide. Ces hypothèses devront donc être vérifiées par des recherches plus avancées.

Schéma de traitement

Le schéma de traitement à sec des rejets d'amiante suit une technique d'usinage standard de tamisage et de récupération avec seulement une étape de concassage à impact (pour le développement des spécules). Le nettoyage et l'ouverture de la fibre se fait par l'équipement standard de tamisage, d'ouverture et de dépoussiérage. La fibre est produite à 1% d'humidité.

Le schéma de traitement humide comprend deux étapes de récupération de la fibre en utilisant des cônes séparateurs et trois étapes de nettoyage, c'est-à-dire deux étapes à l'aide de trommel de lavage et une étape à l'aide de tables gravimétriques. La fibre et les résidus fins sont passés dans des filtres presse pour enlever l'eau. La fibre est ensuite asséchée à un niveau de 10% d'humidité.

Coût d'investissement

L'ordre de grandeur du coût d'investissement des deux usines de traitement fut estimée comme suit:

Usine de traitement à sec	$19.1 millions
Usine de traitement humide	$13.8 millions

L'allocation normale de 10% pour les imprévus de construction d'usine de traitement à sec a été majorée à 25% pour l'usine de traitement humide pour tenir compte de l'état conceptuel de son développement.

Coût d'exploitation

L'ordre de grandeur des coûts d'exploitation des deux usines furent estimés comme suit:

Usine de traitement à sec	$11.0 millions
Usine de traitement humide	$ 8.7 millions

On peut conclure que pour l'usine de traitement humide:

1. Le coût de la main d'oeuvre est moindre en raison d'une plus petite équipe.

2. Le coût de l'entretien est plus bas parce qu'il y a moins d'équipement.

3. Le coût de l'électricité est moins élevé en raison d'une plus faible demande.

4. Le coût du séchage est plus bas.

Revenu

Les revenus ont été calculés en tenant compte de la force de la fibre (FSU) ajustée selon le pourcentage d'humidité dans la fibre et du prix de liste de 1985 réduit de 25%.

La production de l'usine de traitement à sec produit de la fibre de qualité 5R (85 FSU) et 6D (75 FSU). Les tests préliminaires ont montrés que la qualité de la fibre de l'usine de traitement humide serait équivalente au 4T (110 FSU) et 5R (85 FSU).

Les revenus annuels se résument comme suit:

Usine de traitement à sec	$13.2 millions
Usinage de traitement humide	$18.3 millions

L'évaluation économique a été faite en assumant une période de production de 10 ans, sans inflation et tenant compte de l'impôt fédéral et provincial de la Colombie-Britannique (53.5%).

Les taux de rendement actualisé (ROI) des deux concepts est le suivant:

Usine de traitement à sec	0.0%
Usine de traitement humide	47.0%

Conclusion

On doit mentionner que l'ordre de grandeur des calculs est basé sur plusieurs hypothèses, néanmoins l'étude démontre que:

a) Une usine de traitement à sec des rejets produisant 30,000 tm de fibre par année, contenant 5% de fibre d'amiante récupérable du groupe 5R et 6D, est non rentable.

b) Une usine de traitement humide des rejets de même capacité, contenant 5% de fibre d'amiante récupérable du groupe 4T et 5R est un projet économiquement viable si les hypothèses peuvent être confirmées par des travaux subséquents.

c) Des recherches additionnelles sur une plus grande échelle sont justifiées pour confirmer les hypothèses de production.

2.0 INTRODUCTION

On July 31, 1985, Kilborn et Associés Ltée was requested by CANMET - Mineral Sciences Laboratories to carry out a technical review and to develop a preliminary capital and operating cost estimate comparison of asbestos wet and dry milling processes. CANMET has been interested in the wet processing of asbestos for many years and this study is to help assess the possible pros and cons of the wet process over the dry recovery of fibre.

Laboratory scale wet processing has been carried out by the Ontario Research Foundation (ORF) and by several asbestos producers and findings of their research has formed the basis for the flowsheet development in a pilot plant (laboratory scale) at Cassiar Asbestos as well as for this study.

Kilborn has made various scale-up assumptions in order to prepare parameters for the conceptual design of the wet processing plant. Kilborn's experience in dry processing of asbestos was the basis for the conceptual design of the dry processing mill. Order of magnitude capital and operating cost estimates were prepared which were used in a comparative economic evaluation.

3.0 SCOPE OF STUDY

Asbestos fibres are generally produced by dry milling processes. One exception is a relative small wet process plant in Yugoslavia, for which little information is available. A wet process plant, producing short asbestos fibres for Union Carbide in California, U.S.A., has recently discontinued operations.

In the early 1950's a wet processing plant operated by Johnson Company Ltd. processed asbestos tailings. This plant, treating 1000 st/day, was in operation in Thetford Mines, Quebec for about three or four years.

A wet process developed in Australia, by Woodsreef Mines Ltd. for ore and tailings, has not yet been commercially exploited. Various other Canadian companies have done research work on the wet process but no commercial plants were built.

The recovery of asbestos fibres from primary ores requires a succession of crushing, impact milling and screening. The fibre recovery from dry mill tailings can be carried out omitting the primary comminution stages.

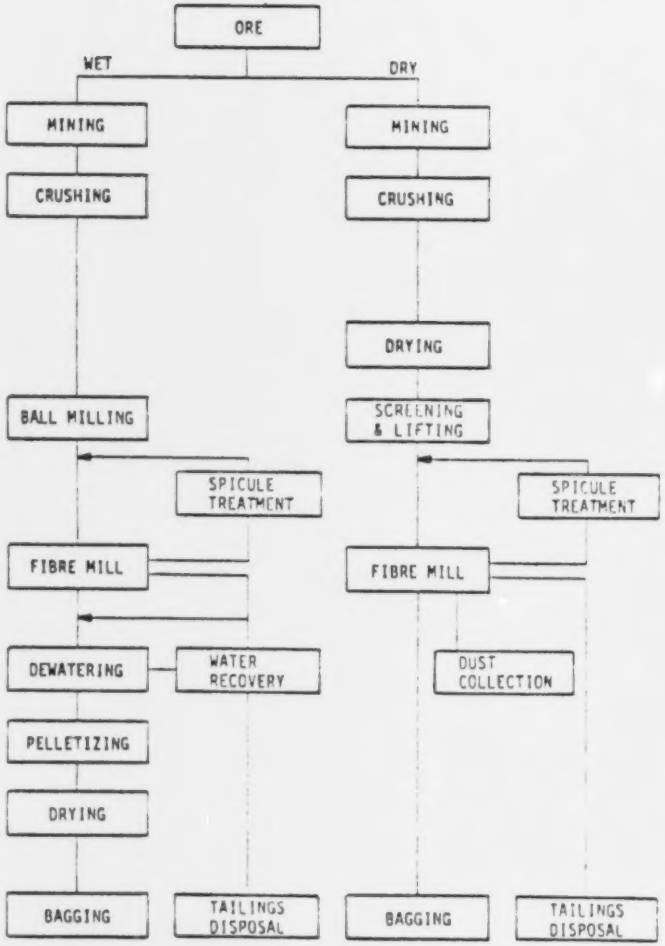
A comparative study for fibre recovery from primary ores would therefore be somewhat different in scope.

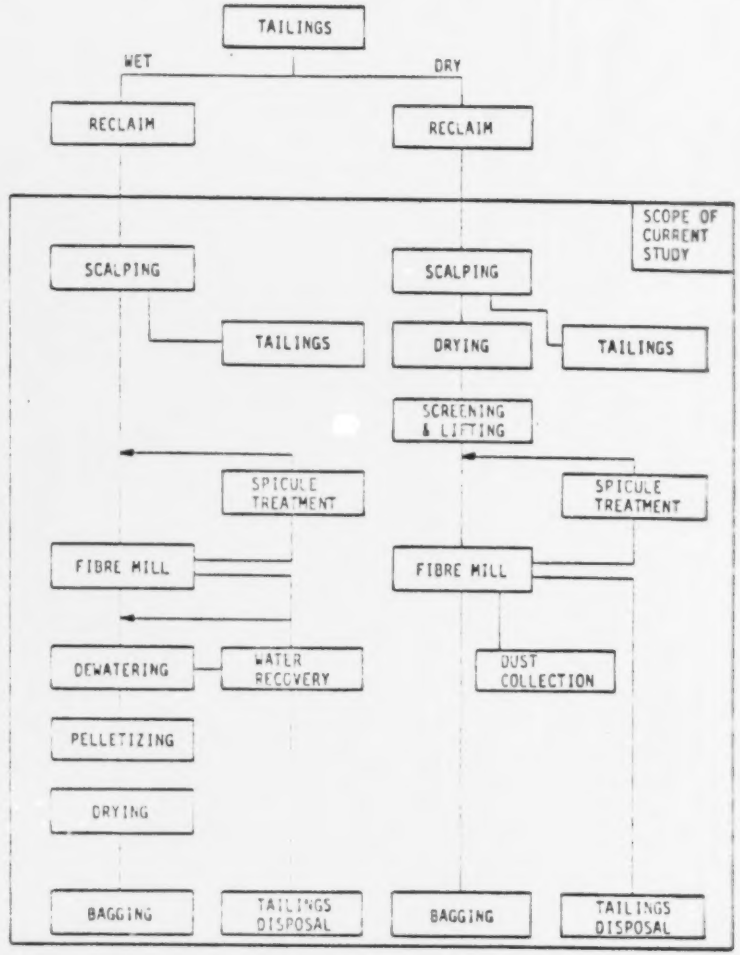
CANMET's mandate to Kilborn entails the study and the cost comparison of an asbestos fibre recovery plant, with a capacity of 600,000 metric tonnes of asbestos tailings and recovery of 30,000 metric tonnes of asbestos fibre per year. Figure 3-1 illustrates the scope of the study in relation to wet and dry processing of asbestos ore and tailings.

figure 3.1

COMPARATIVE REQUIREMENTS

WET VS DRY ASBESTOS MILLING





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4.0 DESIGN PARAMETERS AND ASSUMPTIONS

4.1 LABORATORY FLOWSHEETS

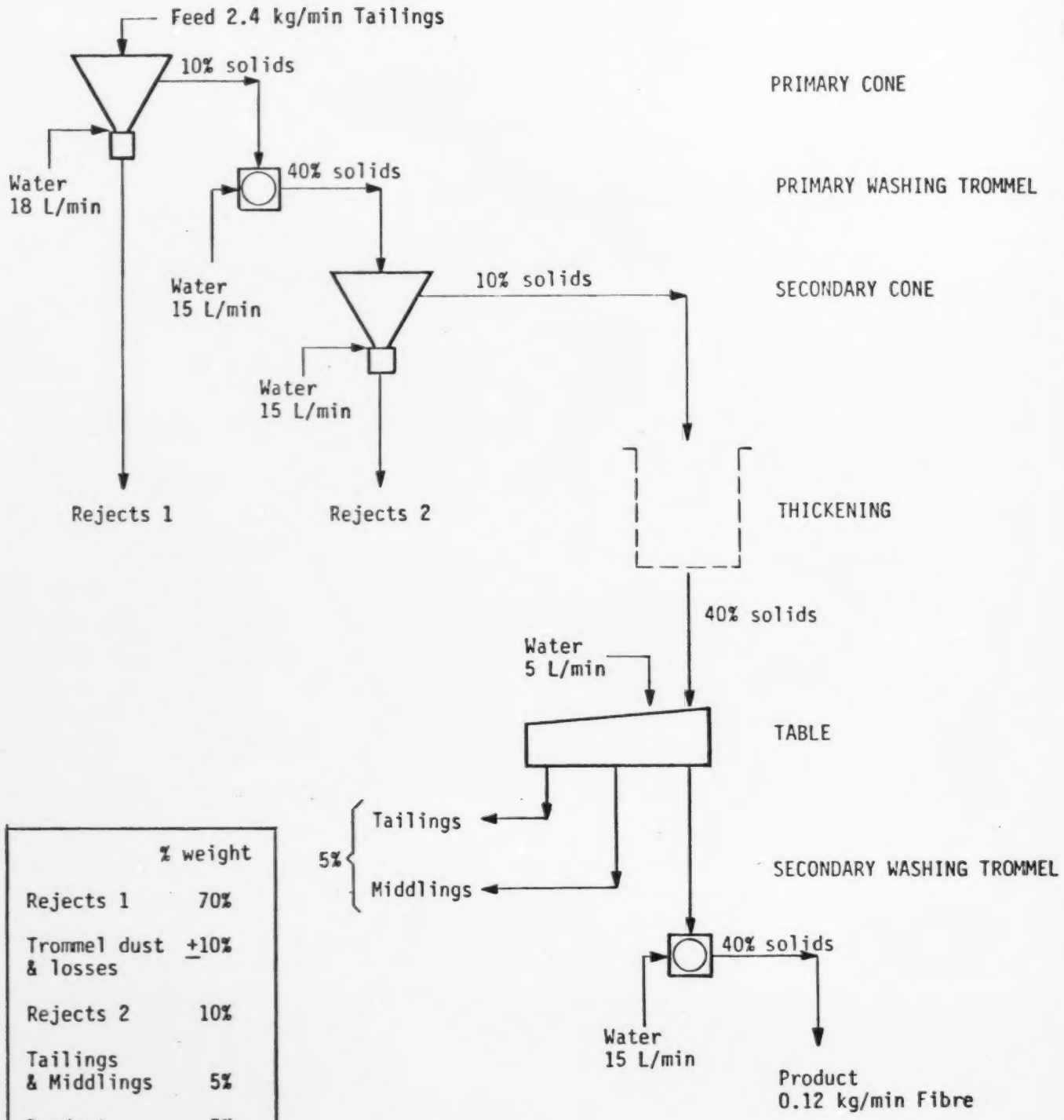
Research work on a wet asbestos fibre recovery process from dry mill tailings was carried out in the Ontario Research Foundation (ORF). Flowsheets for the process were provided by the Scientific Authority of CANMET. All equipment was laboratory size and consisted principally of two elutriation cones approximately one foot in diameter, a washing trommel one foot in diameter by 3 feet long, and a laboratory size Deister gravity table 2 feet x 4 feet.

Various combinations were tried and the most successful flowsheet is shown in Figure 4-1. Cassiar Asbestos subsequently developed with CANMET, a laboratory size test plant of their own in which a small diameter cone with overflow launder was built as well as a washing trommel. A small laboratory size gravity table was also used. The main difference between the ORF and Cassiar flowsheets was the use of one cone only and dust removal (-200 mesh) in two stages instead of one. The Cassiar flowsheet is shown in Figure 4-2.

Satisfactory results have been obtained by both methods and to achieve productive flexibility it was mutually decided by CANMET and Kilborn, to scale-up a combination of the two laboratory flowsheets.

FLOWSHEET

ONTARIO RESEARCH FOUNDATION



	% weight
Rejects 1	70%
Trommel dust & losses	±10%
Rejects 2	10%
Tailings & Middlings	5%
Product	5%
Water consumption 68 L/min	

FIG. 4.1

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CASSIAR FLOWSHEET

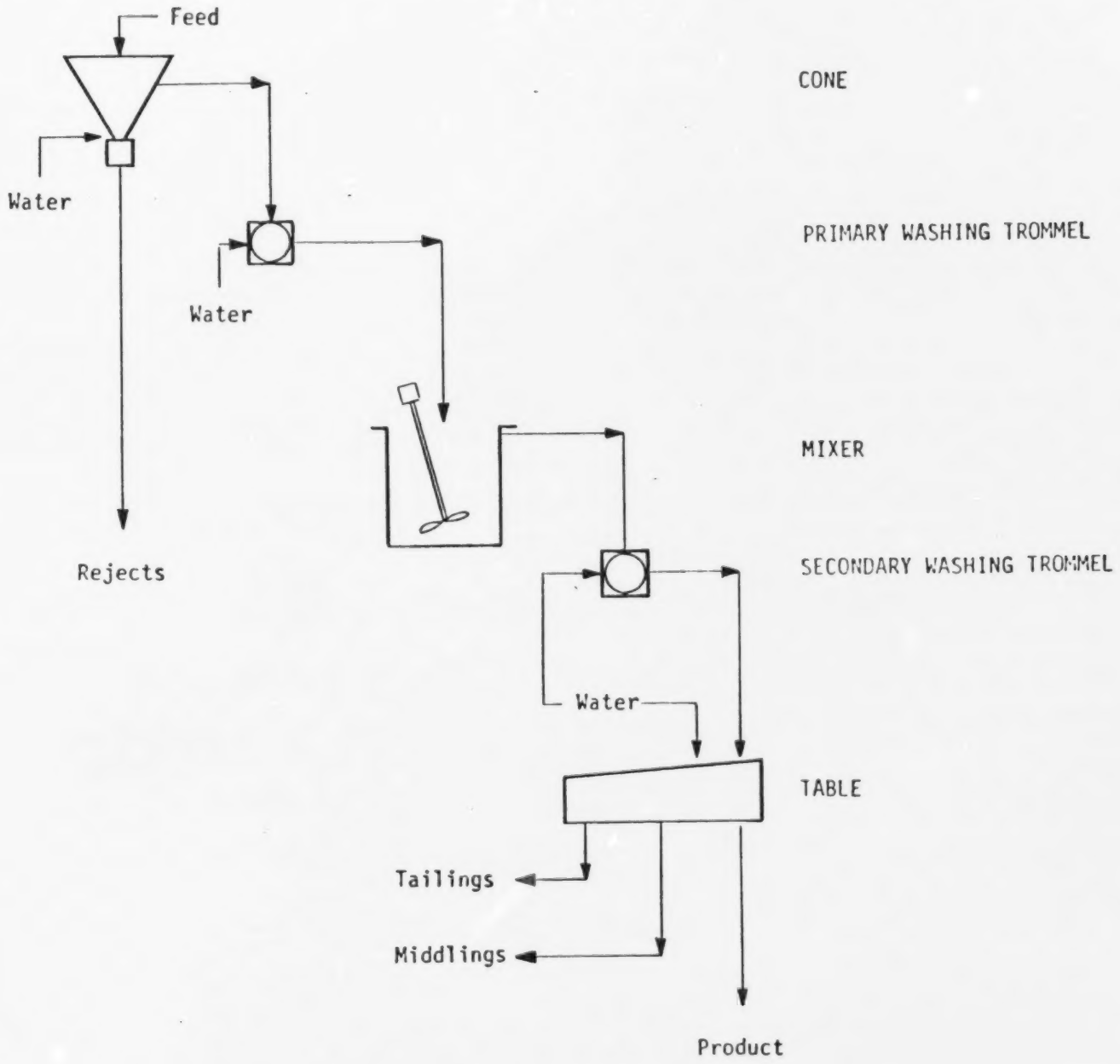

FIG. 4.2

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4.2 DESIGN PARAMETERS

In order to develop capital and operating cost comparisons for a wet and dry processing plant for asbestos tailings, the following parameters were developed:

Common Parameters

Annual tonnage tailings feed	600,000 mt
Hours/day	24 hours
Days/year	250 days
Hourly feed	100 mt/hour
Recoverable fibre content in tailings	5%
Annual fibre production capacity	30,000 mt

Dry Mill Parameters

The design follows standard dry milling principles.

Primary crushing		N/A (tailings feed)
Secondary crushing		N/A (tailings feed)
Drying		- 1/4" material
Rejection		+ 1/4" material
Rocklines:	fiberizing	one stage (spicule treatment)
Fibrelines:	fibre screening	three stages
	dedusting	two stages
	fibre opening	three stages
Dry fibre products		12,000 mt 5R/year
		40% -200 mesh
		FSU 85
		18,000 mt 6D/year
		50% - 200 mesh
		FSU 72
Assumed moisture tailings feed		6%
Assumed moisture fibre product		1%

Wet Mill Parameters

Rejection		+ 1/4" material
Primary cones	overflow	10% solids
	underflow	60% rejects @ 90% solids
Primary washing trommels	overflow	40% solids
	underflow	10% rejects @ 0.74% solids
Secondary cones	overflow	10% solids
	underflow	67% rejects @ 85% solids
Secondary washing trommels	overflow	40% solids
	underflow	24% rejects @ 1.5% solids
Table capacity (double deck)		0.7 mt/hour/deck
Belt filter press	feed	10% solids
	filter cake	65% solids
Dryers feed		65% solids
discharge		90% solids
Wet fibre products		12,000 mt 4T/year 10% -200 mesh 110 FSU 18,000 mt 5R/year 10% -200 mesh 85 FSU
Assumed moisture tailings feed		6%
Assumed moisture fibre product		10%

4.3 SCALE-UP ASSUMPTIONS AND EQUIPMENT SELECTION

No scale up assumptions were necessary for the dry mill and equipment selection was based on standard dry milling procedures. For the wet mill, however, no standard equipment exists and the information consists of laboratory data. For this reason some scale-up assumptions were made as follows:

Cones

The cones tested in the ORF and Cassiar were approximately 1 foot diameter and had a capacity of 2.4 kg/min (= 0.145 tonnes/hour). The capacity of a four feet diameter cone was increased to 2.32 tonnes/hour. The overflow is discharged into a circular overflow launder around the cone.

Washing Trommels

The washing trommels tested were one foot diameter by 3 feet long and about half of the length of the surface was covered by water sprays. The production size trommel was enlarged to 3 feet in diameter by four feet long with a spray area of 3 feet.

Gravity Table

The small size tables used in the ORF laboratory were increased to a 8' x 16' surface deck. In order to save space, two deck Deister tables were used in the design.

Cone Discharge

The underflow of the primary and secondary cones are discharged into a totally enclosed horizontal screw conveyor system which subsequently goes to an angled screw arrangement for discharge about three (3) feet above the rim of the cone overflow launder. These screw conveyors are equipped with vari-speed drives.

Tailings Thickener

All discharges of the washing trommels, containing -200 mesh material, are pumped into a 25 meter diameter thickener, four (4) meters high. The overflow is used for recirculating water while the underflow is fed to filter presses.

Belt Filter Presses

The fibre products as well as the thickener underflow (waste) are directed to separate belt filter presses. Capacity of each filter press is 3 mt/hour and two (2) presses are required for the fibre products and two (2) for the thickener underflow (tailings).

The filter cake will contain 65% solids. Belt filter presses were chosen over the Larox system due to lower capital cost and reported lower operating and maintenance costs. Although testing with the Larox system showed a lower moisture content in the filter cake (30% versus 40-35% for the belt filter) the difference was considered too small to justify the increased capital expense.

Dryer

The filter cake of the fibre product will be dried to a 10% moisture content. In the conceptual flowsheet an extruder - belt dryer has been chosen. Other drying systems are available and should be investigated.

Baggers

Because of the pellet size fibre product and its higher moisture content, a less complicated bagging system can be used in the wet mill. Further test data is required before the actual machine is chosen, but a lower capital cost has nevertheless been used.

5.0 FLOWSHEET DESCRIPTION

5.1 DRY MILL

Following is a short description of the dry milling process flowsheet. The details are shown in drawing 10-F-01 of Appendix A-1. Dry mill tailings produced in the existing Cassiar mill form the basis for the concept.

The tailings will be fed onto a belt conveyor which transports them to a double deck screen in the dryer section of the mill. The +1/4" product amounting to 25% of the feed, is rejected as waste, while the -1/4" accepts will be stored in a surge bin. This product is fed, by a belt feeder, into a 2.4 m Ø x 14.2 m rotary dryer, to reduce the moisture content of the mill feed to approximately 1%. The dryer is equipped with a 40,000 cfm dust collection system.

The dried product is fed by a conveyor belt system into a bucket elevator which transports the material to the main mill feed belt conveyor and into a 4-way distributor.

From the distributor the material is fed into four (4) double deck gyratory rockline screens where the free fibre is lifted.

The unders of these screens go to tails while the mids are screened again. The overs bypass this second screening phase and are fiberized, together with the mids and overs of the second screening stage, in a Torrey fiberizer. After fiberizing, the material is screened again over four (4) gyratory screens, equipped with a fibre lift. The unders and overs are discarded as waste while the mids will pass over the last rockline screens equipped with fibre lift. All non-lifted material is discarded as waste.

The lifted fibre is collected in two sets of four (4) cyclones; the first two screen lifts form the longest product (5D) while the screens after the Torrey fiberizer, produce the shorter fibre product (6D).

The fibre is cleaned through further screening in the fibre lines and dedusting (removal of -200 mesh) in two sets of four 0.9 m Ø x 2.4 m dedusters.

The shorter fractions of both fibre products are opened in nine (9) turbo fiberizers. The final fibre products are collected in two (2) 10 tonne capacity heavy duty live bottom fibre bins. The fibre is then bagged through four (4) pressure packing machines.

The mill is equipped with a 180,000 cfm dust collection system handling the process as well as the environmental air requirements.

5.2 WET MILL

Following is a brief description of the wet process, while the details, material and water balance are shown on the drawings 10-F-04 and 05 in Appendix B-1.

It is not necessary to dry the mill feed for the wet process. The surge bin, required ahead of the dryer in the dry milling process, is therefore not placed in the wet mill but ahead of the mill feed belt.

The dry mill tailings enter the wet mill and are fed into a double deck screen from where the +1/4" material amounting to 25% of the feed, is discarded as waste. A small amount of water is added to the screen to avoid the creation of dust.

The -1/4" material is discharged into a distribution box where more water is added to the slurry, to reach approximately 40% solids. The slurry is agitated to start the release of fibre. From a second series of four (4) distribution tanks the slurry is fed into thirty-two (32), four feet diameter primary cones which are arranged in sets of eight.

The cones are charged, from a point just above the narrow discharge, with possibly three jets of water which creates a circular and upward water motion. The water stream is assumed to be 4.85 m^3/hour per cone, but further test work on large scale pilot plant units must confirm the water balance throughout this described flowsheet.

The light fraction i.e. fibre, dust, spicules and fine rock, is carried to and over the top of the cone into the overflow launders. The heavier fraction is discarded from the bottom of the cone.

The discharge of the cones is handled through a 355 mm (14") diameter, totally enclosed horizontal screw conveyor to an angled screw conveying system. The angled screw conveyor lifts the discarded material to a discharge point about three feet above the rim of the cones, in order to keep the water in the system rather than lose it with the tailings.

The overflow containing 10% solids is gravity fed into thirty-two (32) washing trommels, where -200 mesh material, is washed from the fibreous slurry with high pressure water jets. Laboratory experiments have shown that the slurry leaving the washing trommels contains about 40% solids. The discharge (underflow) of the trommels is directed to a 25 m diameter x 4 m high thickener located outside the building. From the washing trommels the reduced amount of slurry is fed into a set of sixteen (16) secondary cones for further fibre and rock

separation. The discharge (underflow) of the cones is again discarded through a totally enclosed screw conveying system. The overflows of the cones, containing 10% solids, is directed to four pump boxes on the ground floor. The slurry is agitated in the pump boxes and pumped to four distributors on the top floor for subsequent discharge to sixteen (16) secondary washing trommels for further cleaning. The trommel overflow is discharged in two distribution tanks while the underflow is directed to the thickener located outside the mill.

The slurry, containing the fibre, is transported by gravity to six (6) double deck Deister gravity tables for fibre grading and final removal of spicules, grit and heavy magnetite particles. The magnetite and grit fractions are directed to the tailings filter press (described below) while the spicules are discharged into a rod mill for further development. The rod mill product re-enters the circuit through the pump boxes on the ground floor, for eventual recovery of the fibrous components. Grading into two fibre products is assumed to be made on the tables.

The fibre products, recovered from the Deister tables, are fed separately through two (2) pump boxes and pumps onto two (2) belt filter presses. The slurry entering the presses contains 10% solids and the presses will reduce the moisture content to approximately 35% moisture. The filtrate is pumped from a receiving tank to the thickener. The filter cake is directed to two (2) separate extruder-dryers, where the moisture content is further reduced to about 10%.

As mentioned before, additional drying tests are required to obtain an optimum drying technique.

The fibre pellets are transported via screw conveyors and bucket elevators into a fibre storage bin ahead of the four (4) bagging machines. A 30,000 cfm dust collection system will be installed to ensure that any free fibre, released in the drying and conveying systems, is trapped.

The outside thickener receives the discharge of the washing trommels and the filtrates of the filter presses. The overflow of the thickener is discharged into an overflow tank for recirculation to the mill and the underflow is discarded to tailings. The moisture content of the underflow however, is considered too high for immediate discharge. The underflow is therefore pumped to additional filter presses (2), where the moisture content of the tailings is reduced to 35% before discharge to a tailings disposal area. Table 5-1, on the following page, shows a preliminary material and water balance of the wet processing plant. It should be noted that additional test work on full scale production size equipment is required to confirm this material and water balance for detailed plant design. From this preliminary water balance it is calculated that 614.11 m^3/h of water is circulated in the mill and that 8.92 m^3/h of make-up water is required.

TABLE 5-1
PRELIMINARY MATERIAL AND WATER BALANCE

	Dry/Weight		%	Tonnes/h		
	Tonnes/Hr	%	Solids	Solids	Water	To:
Mill Feed	100.0	100.0	94.0%	100.0	6.4	Screen
Scalping Screen (25% rejects)	100.0	100.0	94.0%	100.0	6.4	Distribution/ Rejection
Distribution	75.0	75.0	38.5%	75.0	119.8	Primary Cones
Rejection	25.0	25.0	97.6%	25.0	0.6	Tails/water loss
	100.0	100.0		100.0		
Primary Cones (32x) (60% rejection)						
Water supply to cone	---	---	---	---	155.2	
Overflow	30.0	40.0	10.0%	30.1	270.1	Prim. trommels
Underflow	45.0	60.0	90.0%	45.1	5.1	Tails/water loss
	75.0	100.0				
Primary Trommels (32x)						
Water supply spray	---	---	---	---	172.8	
Overflow	27.0	90.0	40.0%	26.9	40.6	Sec. cones
Underflow	3.0	10.0	1.0%	2.9	402.2	Thickener
	30.0	100.0				
Secondary Cones (16x) (67% rejection)						
Water supply to cone	---	---	---	---	43.7	
Overflow	9.0	33.0	10.0%	9.0	81.0	Sec. trommels
Underflow	18.0	67.0	85.0%	18.1	3.2	Tails/water loss
	27.0	100.0				
Distribution (add grit)	10.6	100.0	10.9%	10.6	85.5	Sec. trommels
Secondary Trommels (16x)						
Water supply spray	---	---	---	---	86.4	
Overflow	8.0	76.0	40%	8.0	12.0	Deister tables
Underflow	2.5	24.0	2%	2.6	159.8	Thickener
	10.5	100.0				
Deister Tables						
Water supply	---	---	---	---	42.0	
Product	5.0	63.0	10%	5	45.0	Filter press
Regrind	1.5	18.5	25%	1.5	4.5	Rod mill
Grit	1.5	18.5	25%	1.5	4.5	Tailings press
	8.0	100.0				

6.0 CAPITAL COST ESTIMATES

6.1 SUMMARY

The order of magnitude capital cost of the dry and wet processing plant treating 600,000 metric tonnes of tailings per year, recovering 5% (300,000 metric tonnes) of fibre out of the mill feed are estimated as follows:

Dry mill	$19.1 million
Wet mill	$13.8 million

The estimate is based on tailings being the mill feed. The crushing and impact crushing stages necessary for a dry mill, as well as that which is required for tailings disposal, are excluded. The equipment installation cost is based on a labour cost estimated to be applicable for a location such as the Cassiar mine in Northern British Columbia. The equipment cost is based on recent budget quotations where applicable or on Kilborn estimates for some of the scaled-up equipment for the wet mill process plant.

6.2 DRY MILL CAPITAL COST

The order of magnitude capital cost estimate for the dry milling plant is based on the flowsheet and conceptual layout drawings shown in Appendix A-1. The details of the capital cost calculation are attached as Appendix A-2. Dry milling plants are generally high structures, due to the fact that transport of fibre containing rock is done by gravity. Unneccessary rehandling of this material results in additional opening of fibre and dust impregnation which should be avoided. This conceptual design

calls for a seven storey high building with a total height of 44.5 meters. The conveyor belt feeding the plant is included in the estimate while the equipment mining and transporting the dry tailings are excluded. All the structures such as mill building and dryer building and the equipment within these structures are included. The bag handling system and tailings disposal system would be identical for both plants and is for this reason excluded and the tailings disposal system.

Table 6-2 is a summary of the order of magnitude capital cost estimate:

TABLE 6-2
CAPITAL COST - DRY MILL

Description	Cost
Site Work	$ 55,000
Building & Structures	5,391,000
Building Services	300,000
Mechanical Equipment, including ducting	8,848,000
Process Piping for dryer	25,000
Electrical & Instrumentation	500,000
Total Direct Cost	$15,119,000
Engineering + Indirect Cost 15%	2,268,000
Contingencies 10%	1,738,000
TOTAL COST	$19,125,000

6.3 WET MILL CAPITAL COST

The order of magnitude capital cost estimate for the wet milling plant is based on the flowsheets and conceptual layout drawings shown in Appendix B-1. The details of the capital cost calculation are attached as Appendix B-2.

The dry milling technique to use gravity as much as possible is also applied in the design of the wet mill where one lifting stage only is used. The height, and thus the cost, of the wet mill building could probably be reduced if standard wet process techniques, such as slurry transfer through pumping, were implemented. Due to the fact that no drying is required prior to processing, a surge bin is installed before the main mill feed belt conveyor. The capital cost estimate includes this bin and belt feeder as well as the mill feed conveyor.

The mill building is five floors high for a total of 34 meters. All equipment in the building, with the exception of the bag handling system, is included in the estimate. The tailings belt, transporting the wet tailings to a tailings dump is excluded because the site for tailings disposal would be the same in both cases. The cost is therefore considered equivalent to that of the dry disposal system.

However, due to the fact that more moisture is discharged with the wet system, an allowance for a retaining dam and pumps is included in the cost estimate. Furthermore, the normal contingency of 10% is increased to 25% for the wet process plant, to reflect the more conceptual nature of the design.

Table 6-3 is a summary of the order of magnitude capital cost estimate:

TABLE 6-3
CAPITAL COST - WET MILL

Description	Cost
Site Work	$ 32,000
Building & Structures	2,566,000
Building Services	200,000
Mechanical Equipment	5,305,000
Process Piping	765,000
Electrical & Instrumentation	460,000
Tailings Disposal	250,000
Total Direct Cost	$ 9,578,000
Engineering + Indirect Cost 15%	1,437,000
Contingencies 25%	2,753,000
TOTAL COST	$13,768,000

7.0 OPERATING COST ESTIMATES

7.1 SUMMARY OF ANNUAL OPERATING COSTS

The annual operating costs can be divided into the costs which are common to both methods and the other operating costs which vary with the milling method.

The summary of the total estimated annual operating costs is shown in table 7-1.

TABLE 7-1
SUMMARY OF ANNUAL OPERATING COSTS

	DRY MILL		WET MILL	
	Total	Per MT Fibre (30,300 MT/y)*	Total	Per MT Fibre (33,333 MT/y)*
Tailings reclaim	1,800,000	59.41	1,800,000	54.00
Direct overhead	600,000	19.80	600,000	18.00
Laboratory costs	260,000	8.58	260,000	7.80
Tailings disposal	300,000	9.90	300,000	9.00
General administration	925,000	30.53	925,000	27.75
Marketing	315,000	10.40	315,000	9.45
Mill labour	2,600,000	85.81	1,800,000	54.00
Maintenance labour	1,080,000	35.64	920,000	27.60
Maintenance supplies	442,000	14.59	241,000	7.23
Power	683,000	22.54	325,000	9.75
Drying	1,605,000	52.97	850,000	25.50
Bagging	364,000	12.00	400,000	12.00
	$10,974,000	$362,17	$8,736,000	$262.08

* Tonnage reflects moisture content of 1% and 10% respectively.

7.2 OPERATING COSTS COMMON TO BOTH METHODS

7.2.1 Tailings Reclaim Cost

The tailings will be reclaimed by front end loader and handled by truck to a hopper located near the mill.

The annual cost has been estimated as follows:

Loading	$ 1.25/mt mill feed	
Handling	$ 1.75/mt mill feed	
Total	$ 3.00/mt mill feed	$1,800,000

7.2.2 Direct Overhead

The direct overhead consist of supervisory staff safety personnel, first aid, security, etc. and the total annual cost has been estimated at $ 600,000

7.2.3 Laboratory Costs

The annual cost for the fibre laboratory has been estimated at $ 260,000

7.2.4 Tailings Disposal Cost

The annual cost of tailings disposal is based on the discharge of tailings by conveyor belt for both processes. The annual cost is estimated at $ 300,000

7.2.5 General Administration

The total annual cost of administrative personnel and communications, accounting, etc. is estimated at $ 925,000

7.2.6 Marketing Cost

The total annual cost has been estimated at $ 315,000

7.3 OTHER DRY MILL OPERATING COSTS

7.3.1 Labour costs

For this comparative estimate it has been assumed that the dry mill labour force would consist of sixty-five (65) hourly labourers each earning an average annual salary, including benefits, of $40,000/year.

Total annual cost $2,600,000.

The maintenance labour is estimated to consist of twenty-seven (27) hourly labourers each earning $40,000/year.

Total annual cost $1,080,000.

7.3.2 Maintenance supplies

The maintenance supplies are calculated as 5% of the mechanical equipment installed in the dry mill.

Total annual cost $442,000

7.3.3 Power cost

Table 7-2 shows the connected horsepower and the power cost calculation for the dry mill.

TABLE 7-2
CONNECTED HP DRY MILL

	Per Unit	No. of Units	Total
Belt Conveyor	10	1	10
Screen	5	1	5
Belt Feeder	10	1	10
Rotary Dryer	150	1	150
Distributor	3	1	3
Screens	5	28	140
Torrey Fiberizer	100	4	400
Airlocks	3	16	48
Dedusters	10	8	80
Turbo Fiberizers	40	9	360
Bagging Bin Screws	3	2	6
Packing Machines	75	4	300
Conveyor Belts	5	12	60
Bucket Elevators	15	3	45
Screw Conveyors	5	6	30
Dust Collector Fans	150	3	450
Dust Collector Screws	5	2	10
Dust Collector Airlock	3	1	3
Tailings Belt	10	1	10
TOTAL			2120

Power Consumption = Total Connected HP
x Power Factor (.9)
x kW Factor (.746)
x Hours per Year (6000)
x Price Per kWHr ($0.08) $683,215/year
say $683,000

7.3.4 Drying cost

Drying cost is based on rotary dryer cost from Lake Asbestos, where the drying energy is provided by Bunker "C" oil (heating value 0.041×10^6 BTU/litre). When it is assumed that the average moisture content of the dryer feed is 6% and that of the dryer output is 1%, the required average annual energy over 10 years was 2.854×10^6 BTU/mt H_2O.

The following calculation determines the annual drying requirements for the dry milling operations:

Dry mill feed contains 6% moisture
All moisture in the fines (75%) which go into dryer
Dryer will bring moisture down to 1%

600,000 mt @ 6% moisture = 38,298 mt H_2O
450,000 mt @ 1% moisture = 4,545 mt H_2O

Removal = 33,747 mt H_2O

$33,747 \times 2.854 \times 10^6$ BTU = 9.63×10^{10} BTU/year

When heating oil (energy value 30,000 BTU/litre and costing \$0.50/litre) is used for drying the annual cost is:

$$\frac{9.63 \times 10^{10}}{30,000} \times \$0.50 = \$1,605,232, \text{ say } \$1,605,000$$

7.3.5 Bagging cost

The bagging cost includes the cost of bags, printing, pallets and wrapping and is estimated at \$12.00 per metric tonne of fibre produced. The dry mill will recover 30,000 metric tonnes of fibre with a moisture content of 1% for a total of 30,300 metric tonnes of fibre. Total annual cost is 30,300 x \$12 = \$364,000.

7.4 OTHER WET MILL OPERATING COSTS

7.4.1 Labour costs

The labour force of the wet mill is smaller because less floor space and less equipment has to be controlled. The force is assumed to have 20 men less, namely:

- 18 floor men (wet mill has three (3) floors against six (6) floors in dry mill, 2 men per floor x 3 shifts),
- 2 cleaners.

Total annual cost (65-20) x $40,000 = $1,800,000

Maintenance labour force is also smaller and the standard dry milling crew is reduced by four (4) men:

3 screen repair men
1 carpenter

Annual maintenance labour cost (27-4) x $40,000 = $920,000

7.4.2 Maintenance supplies

Annual cost for maintenance supplies is estimated at 5% of mechanical equipment installed in the wet mill:

Total annual cost $241,000

7.4.3 Power cost

Table 7-3 shows the connected horsepower and the power cost calculations for the wet mill. It should be noted that although the drying energy is assumed to be supplied by steam from an electric boiler, the drying cost has been separately calculated on the basis of the use of heating oil.

TABLE 7-3
INSTALLED HP WET MILL

	Per Unit	No. of Units	Total
Belt Conveyor	5	1	5
Belt Feeder	10	1	10
Mill Feed Conveyor	10	1	10
Screen	5	1	5
Agitators	5	10	50
Discharge Screws (horizontal)	5	8	40
Discharge Screws (+30°)	7.5	8	60
Washing Trommels	5	48	240
Pumps (2 spares)	3	6(excl. spare)	18
Pumps (3 spares)	10	3(excl. spare)	30
Pumps (1 spare)	15	1(excl. spare)	15
Pumps (1 spare)	75	1(excl. spare)	75
Deister Tables	3	6	18
Rod Mill	50	1	50
Belt Filter Press	30	4	120
Thickener	7.5	1	7.5
Extruder Dryer B	40	2	80
Steam Boiler*	4200	1	4200*
Screw Conveyors	5	4	20
Bucket Elevators	15	2	30
Bagging Bins Screws	3	2	6
Packing Machines	5	4	20
Dust Collector Fans	25	3	75
Dust Collector Screws	5	2	10
Dust Collector Airlock	3	1	3
Tailings Belt	10	1	10
			1007.5

Annual cost is 1007.5 x .9 x .746 x 6000 x $0.08 = $324,689

say, $325,000

* Drying cost calculated separately
(excluded in addition of total HP).

7.4.4. Drying cost

Data supplied for Johnson's wet milling operations showed that drying of wet asbestos from 40% to 1% moisture required 5.104×10^6 BTU/mt H_2O. Drying was done in an eight hearth Nichols Herreshoff dryer. The operation was considered inefficient. More efficient dryers are now available and it is assumed that the wet fibre could be dried using a total BTU which would be the average of the Johnson's wet mill and Lake Asbestos dry mill.

$$\frac{5.104 + 2.854}{2} \times 10^6 = 3.979 \times 10^6 \text{ BTU/mt } H_2O$$

The annual cost is calculated as follows:

Dryer feed from filter press is 30,000 tonnes at 35% moisture
Dryer product at 10% moisture.

30,000 @ 35% moisture = 16,154 mt H_2O
30,000 @ 10% moisture = 3,333 mt H_2O

Removal = 12,821 mt H_2O

12,821 mt x 3.979×10^6 BTU = 5.10×10^{10} BTU/year

In order to compare with the dry milling operation the annual drying cost has been calculated assuming that the same heating oil (energy value 30,000 BTU/litre and costing \$0.50/litre) is used:

$$\frac{5.10 \times 10^{10}}{30,000} \times \$0.50 = \$850,000$$

7.4.5. Bagging

Bagging includes cost of bags, printing, pallets and wrapping and is estimated at $12.00 per metric tonne of wet fibre.

The product contains 10% moisture, the total production therefore is 33,333 metric tonnes.

Annual cost 33,333 x $12.00 = $400,000

8.0 ECONOMIC COMPARISON

8.1 ECONOMIC PARAMETERS

Three cost and revenue parameters are considered, namely: capital cost, operating cost and revenue.

8.1.1 Capital cost

An order of magnitude capital cost for each mill has been calculated in detail in appendices A-2 and B-2 and section 6.0 and is summarized as follows:

Dry mill	$19,125,000
Wet Mill	$13,768,000

Existing equipment will be used for the mining and transportation of the tailings to the mill and the existing tailings belt is used for the disposal of new mill tailings. Cost for this equipment is excluded from the estimates.

The capital for construction is expended in year 1.

8.1.2 Operating cost

The annual order of magnitude operating cost has been calculated in detail in section 7.0 and is summarized as follows:

Dry mill	$10,974,000
Wet mill	$ 8,736,000

8.1.3 Revenue

The revenue of the fibre production is based on preliminary FSU test results at the ORF, a moisture content of 1% and 10% of the dry mill product and wet mill product respectively and a fibre price list of 1985, reduced by 25% for existing discounts.

Preliminary test results of the ORF on the wet milled fibre has shown that two product could be produced as follows:

4T @ 110 FSU
5R @ 85 FSU

The dry fibre production is assumed to test as:

5R @ 85 FSU
6D @ 72 FSU

The fibre prices (1985) are as follows:

Grade	FSU	Price/mt	Discounted Price/mt
4T	110	$1,083	$812
5D	93	838	629
5R	85	711	533
6D	72	521	391
7D	58	308	231

a) Dry mill Production

The dry mill will produce:

2 mt/hour of 5R at 1% moisture
3 mt/hour of 6D at 1% moisture

The tested FSU is reduced due to the 1% moisture content as follows:

2 mt @ 85 FSU = 2.02 mt @ 84 FSU - reduced price $522/mt
3 mt @ 72 FSU = 3.03 mt @ 71 FSU - reduced price $380/mt

Total Annual Revenue

12,120 mt @ $522/mt
18,180 mt @ $380/mt
30,300 mt @ $437/mt = $13,241,000

b) Wet mill production

The wet mill will produce:

2 mt/hour of 4T @ 10% moisture
3 mt/hour of 5R @ 10% moisture

Due to the fact that test results of the ORF have shown that the dust content (-200 mesh) is approximately 10% lower than that of the dry milled fibre, the revenue is based on an increased moisture content as follows:

2 mt @ 110 FSU = 2.2 mt (@ 10%) 100 FSU = reduced price $704
3 mt @ 85 FSU = 3.3 mt (@ 10%) 77 FSU = reduced price $446

Total Annual Revenue

13,333 mt @ $704/mt
20,000 mt @ $446/mt
33,333 mt @ $549/mt = $18,300,000

8.2 ECONOMIC CALCULATIONS

The comparative economic evaluation is calculated for a production period of 10 years and inflation has been excluded.

For the calculation of net cash flow a depreciation allowance up to 100% has been assumed and the federal and British Columbia provincial income taxes as 36% and 17 1/2% respectively.

Calculations of net cash flows, after taxes are shown in table 8-1 and 8-2.

The ROI of the dry mill is calculated at 0.0% while the ROI of the wet mill at 47%.

It should be noted that this is a comparative study and that the above results should be interpreted with caution.

TABLE 8-1
DRY MILL CASH FLOW
('000 dollars)

Year	Capital Cost	Revenue	Op. Cost	Net Revenue	Depr. All.	Net Inc B. Tax	Taxes (53.5%)	(Cash Flow) Net Inc. After Tax
1	19,125	---	---	---	---	---	---	(19,125)
2	---	13,241	10,974	2,267	2,267	---	---	2,267
3	---	13,241	10,974	2,267	2,267	---	---	2,267
4	---	13,241	10,974	2,267	2,267	---	---	2,267
5	---	13,241	10,974	2,267	2,267	---	---	2,267
6	---	13,241	10,974	2,267	2,267	---	---	2,267
7	---	13,241	10,974	2,267	2,267	---	---	2,267
8	---	13,241	10,974	2,267	2,267	---	---	2,267
9	---	13,241	10,974	2,267	2,267	---	---	2,267
10	---	13,241	10,974	2,267	989	1,278	684	1,583

ROI = 0.0%

TABLE 8-2

WET MILL CASH FLOW

Year	Capital Cost	Revenue	Op. Cost	Net Revenue	Depr. All.	Net Inc B. Tax	Taxes (53.5%)	(Cash Flow) Net Inc. After Tax
1	13,768	---	---	---	---	---	---	(13,768)
2	---	18,300	8,736	9,564	9,564	---	---	9,564
3	---	18,300	8,736	9,564	4,204	5,360	3,868	6,696
4	---	18,300	8,736	9,564	---	9,564	5,117	4,447
5	---	18,300	8,736	9,564	---	9,564	5,117	4,447
6	---	18,300	8,726	9,564	---	9,564	5,117	4,447
7	---	18,300	8,736	9,564	---	9,564	5,117	4,447
8	---	18,300	8,736	9,564	---	9,564	5,117	4,447
9	---	18,300	8,736	9,564	---	9,564	5,117	4,447
10	---	18,300	8,736	9,564	---	9,564	5,117	4,447

ROI = 47.0%

9.0 CONCLUSIONS AND RECOMMENDATIONS

The capital cost and operating cost estimates are of an order of magnitude only and should not be taken as absolute. The economic evaluation must therefore be interpreted with caution.

Although the comparative study has been based on various unconfirmed scale-up assumptions for the wet process mill, the evaluation has shown that:

a) A dry plant for tailings producing about 30,000 mt of fibre per year, based on 5% recoverable 5R and 6D asbestos fibres, is approximately a break-even project.

b) A wet plant for tailings based on 5% recoverable 4T and 5R (lower -200 mesh) asbestos fibres is an economic viable project, if the assumptions can be confirmed.

The above conclusions suggest that further research appears to be justified and that testing of full scale, production type wet process equipment should proceed.

Following is a short description and cost estimate of the recommended test program.

1) Design of prototype-experimental wet process equipment i.e.

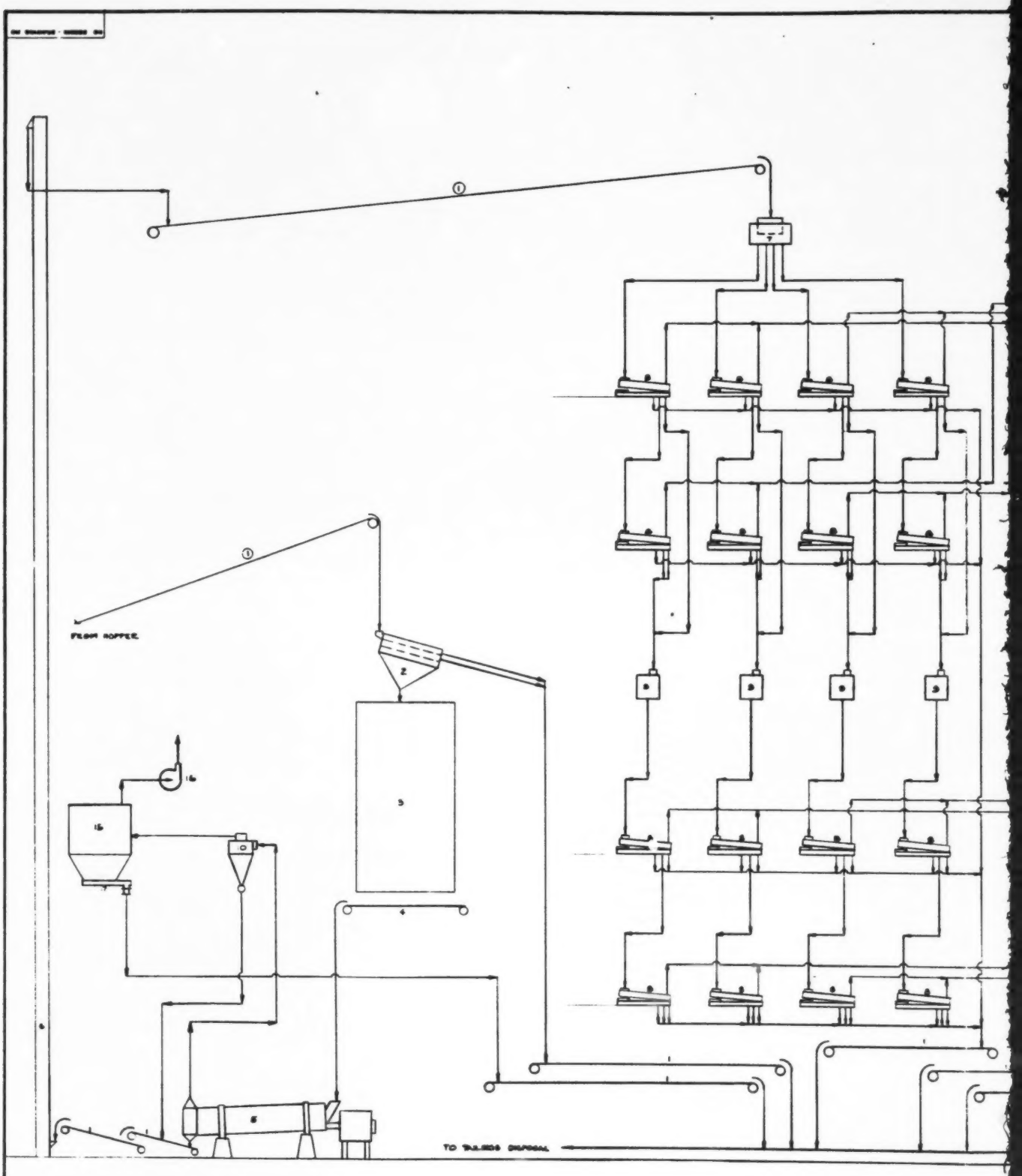
- four (4) feet diameter cone
- horizontal and angled screw conveying system
- three (3) feet diameter by six (6) feet long washing trommel

3 weeks $ 5,000

2) Discussions and review of prototype design.

3) Fabrication of prototype equipment:

- cone and support		$ 4,000
- screw conveyors		12,000
- washing trommel		15,000
	10 weeks	$ 31,000
4) Installation	2 weeks	$ 12,000
5) Testing program	12 weeks	$ 35,000
	Contingency	$ 17,000
		$100,000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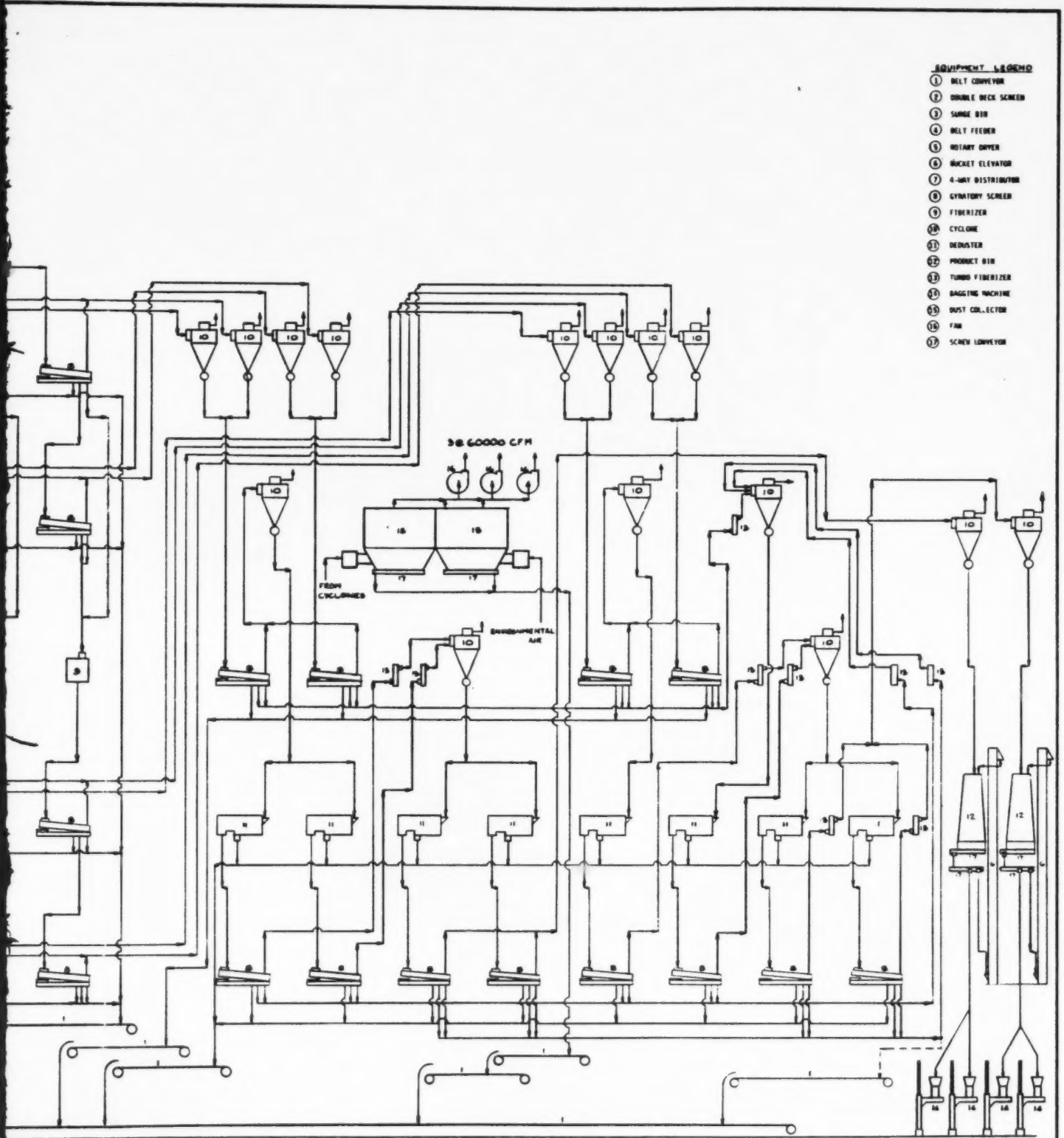

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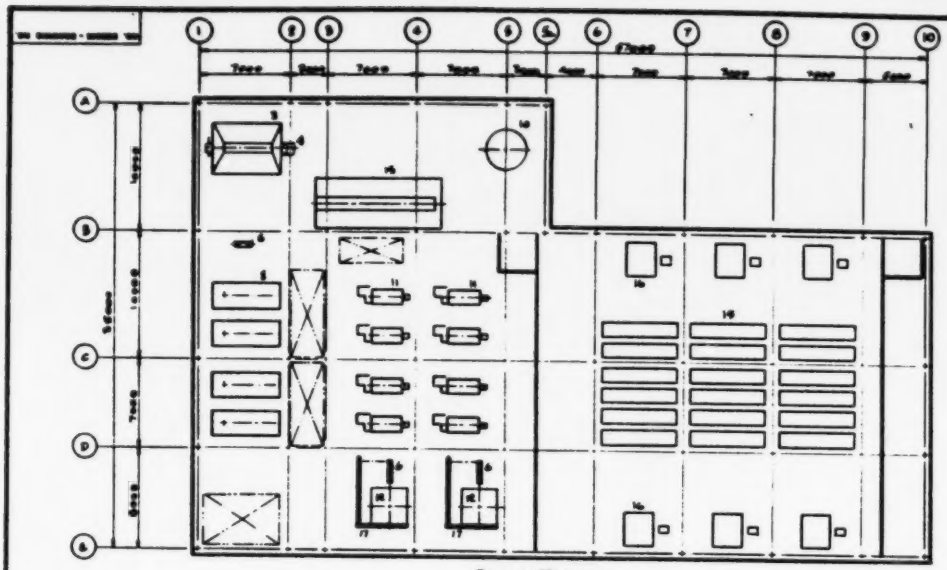
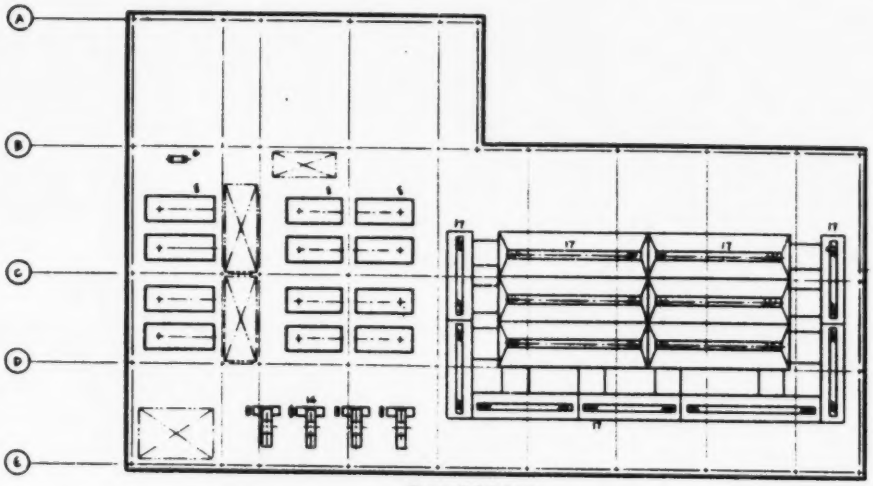
				NO. DESIGN - DRAWING NO. 10-F-01	REV.



PLAN 3RD FLOOR



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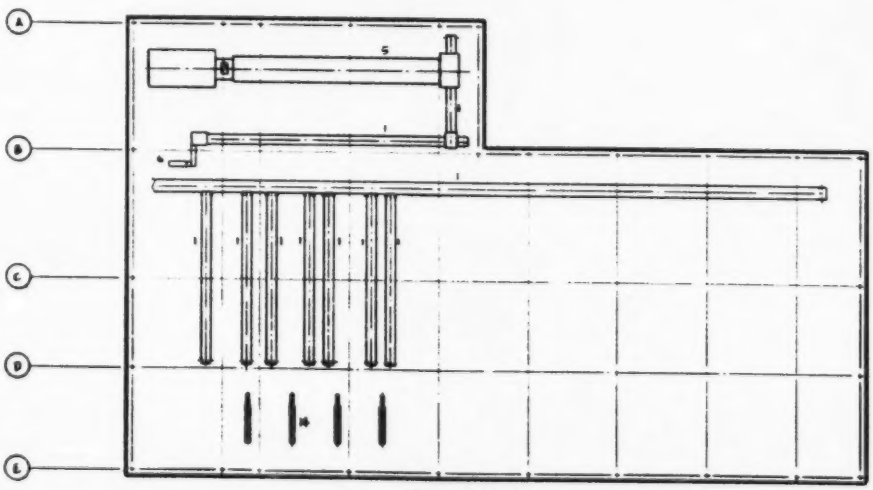
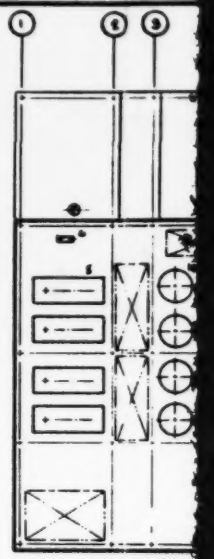
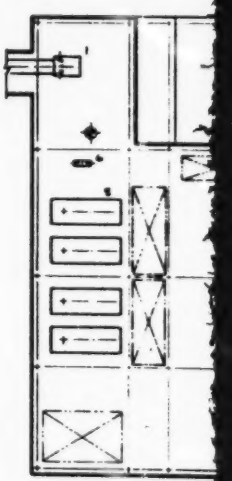
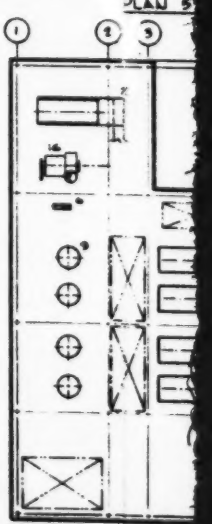
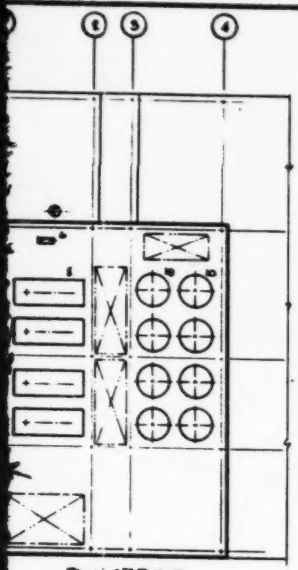


PLAN 1ST FLOOR









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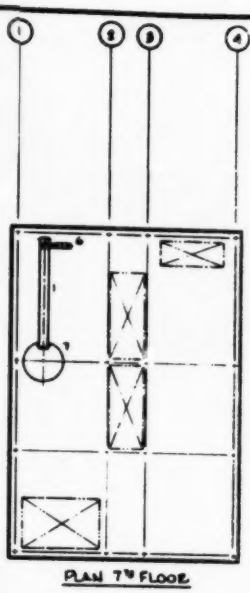
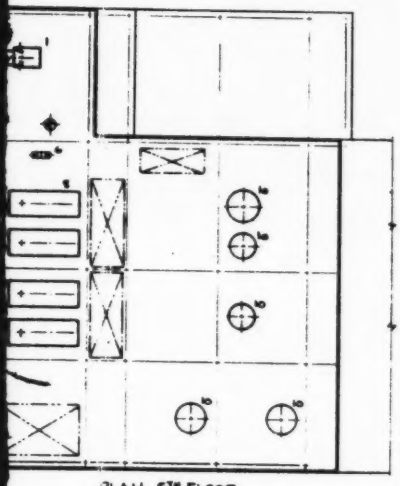
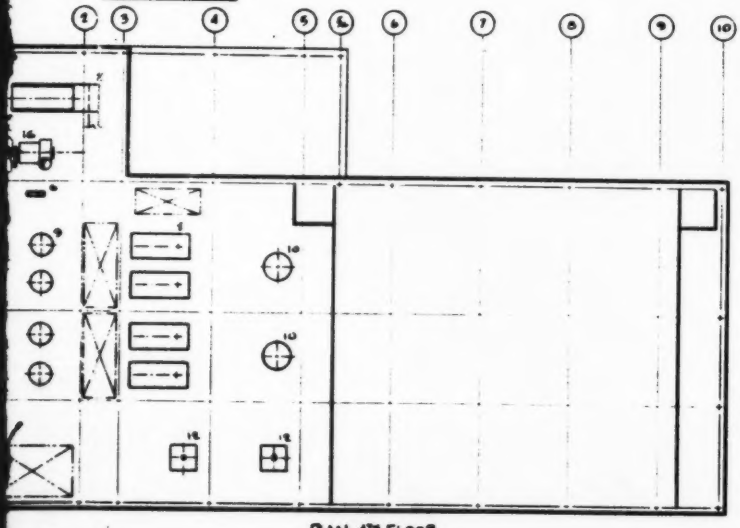


PLAN 7TH FLOOR



PLAN 5TH FLOOR

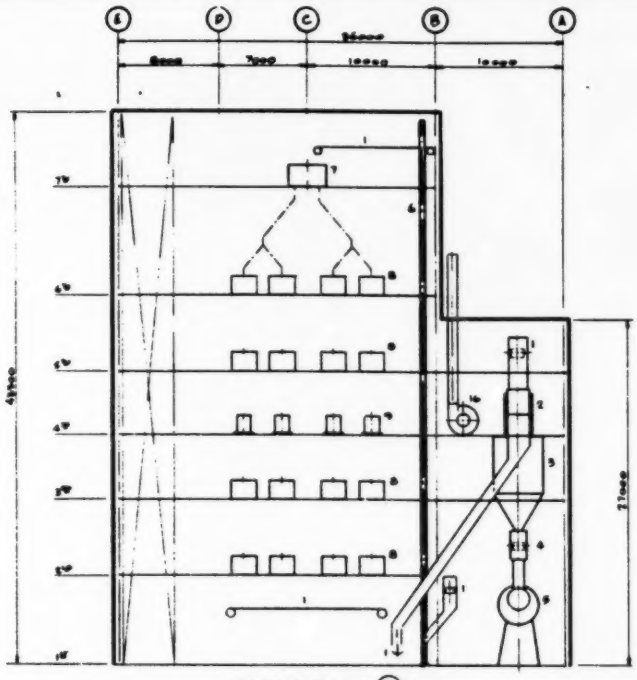


PLAN 4TH FLOOR

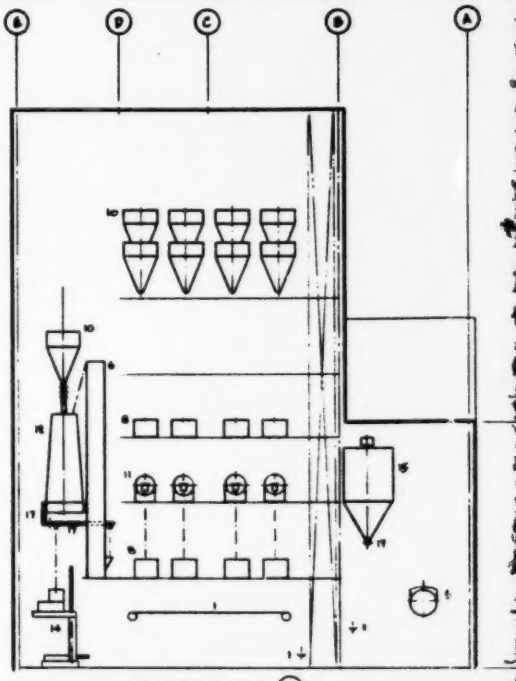
EQUIPMENT LEGEND

1. BELT CONVEYOR
2. DOUBLE DECK SCREEN
3. SURGE BIN
4. BELT FEEDER
5. ROTARY DRYER
6. BUCKET ELEVATOR
7. 4-WAY DISTRIBUTOR
8. GYRATORY SCREEN
9. FIBERIZER
10. CYCLONE
11. DEDUSTER
12. PRODUCT BIN
13. TURBO FIBERIZER
14. BAGGING MACHINE
15. DUST COLLECTOR
16. FAN
17. SCREW CONVEYOR

		GENERAL Layout	CLIENT: CALIMET
		1:100	
			KILBORN
			TITRE - TITLE: 30 000 T.P.Y. ASBESTOS TAILINGS DRY PROCESS MILL GENERAL LAYOUT PLANS
			1096 / 15
			10-F-02



SECTION ON COL. (3)



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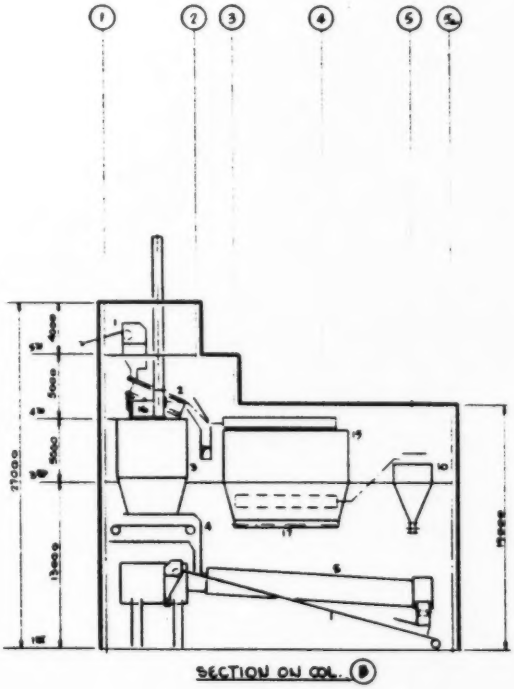
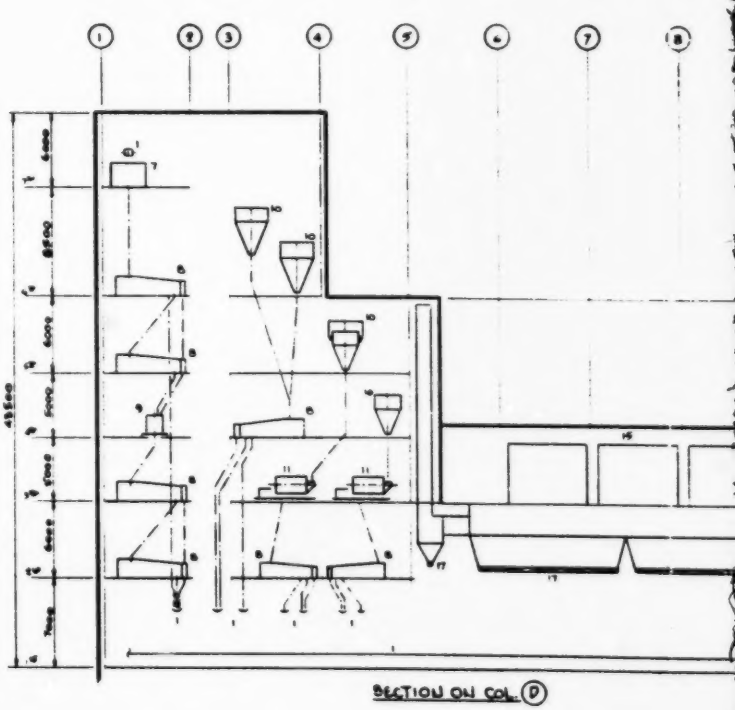
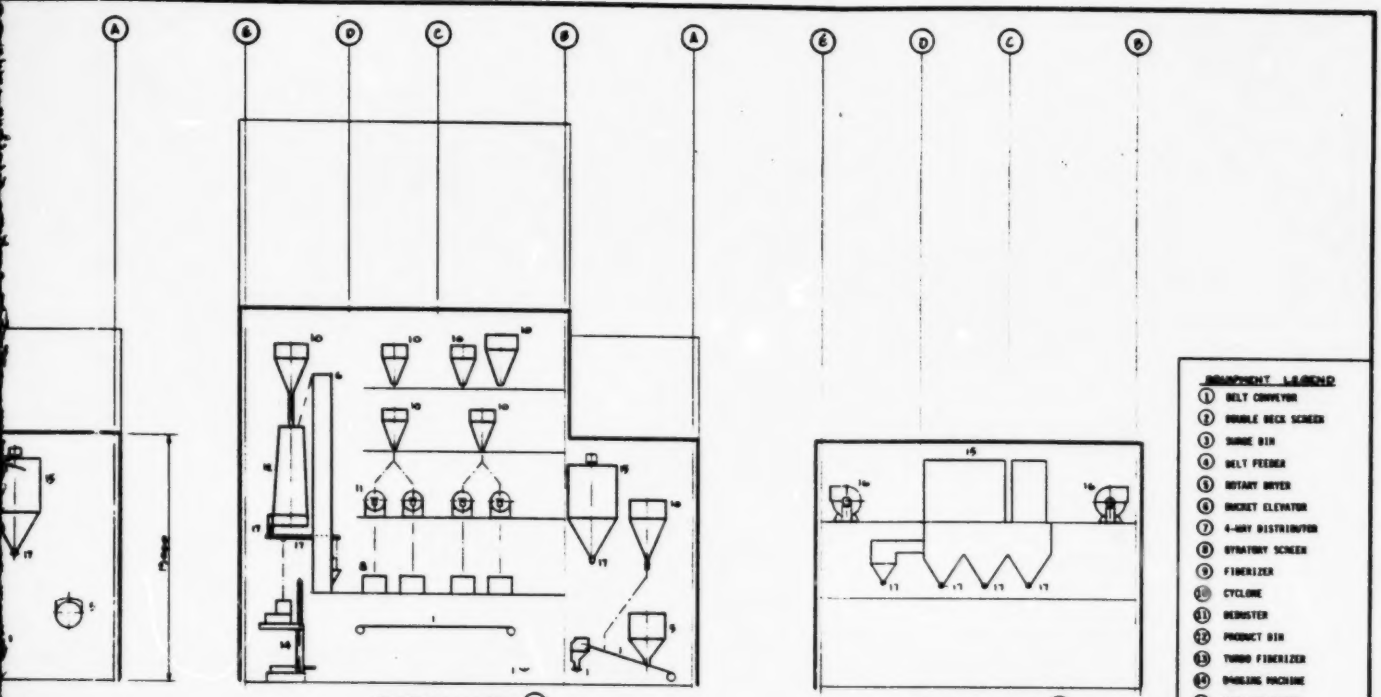


SECTION ON COL. (B)



SECTION ON COL. (D)

DESCRIPTION	DESCRIPTION	DESCRIPTION
DESSINS DE REFERENCE - REFERENCE DRAWINGS	REVISIONS	REVISIONS

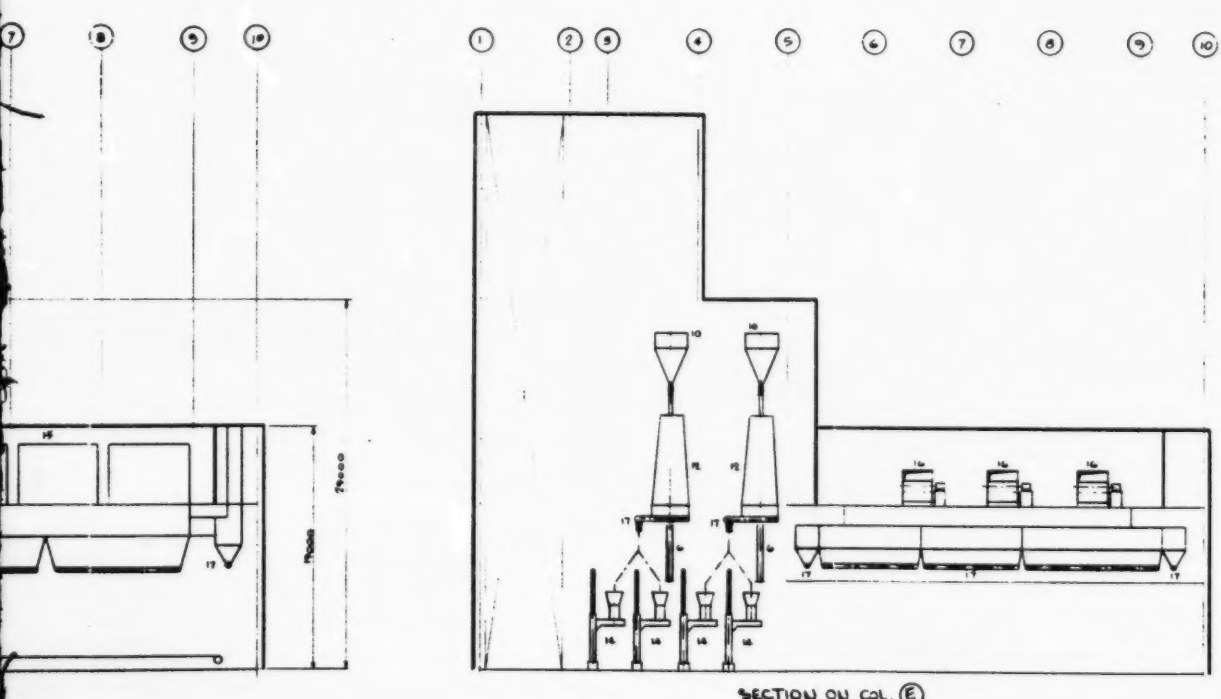


SECTION ON COL. (5)

SECTION ON COL. (5A)

EQUIPMENT LEGEND

1. BELT CONVEYOR
2. DOUBLE DECK SCREEN
3. SURGE BIN
4. BELT FEEDER
5. ROTARY DRYER
6. BUCKET ELEVATOR
7. 4-WAY DISTRIBUTOR
8. GYRATORY SCREEN
9. FIBERIZER
10. CYCLONE
11. BERGSTER
12. PRODUCT BIN
13. TURBO FIBERIZER
14. BAGGING MACHINE
15. DUST COLLECTOR
16. FAN
17. SCREW CONVEYOR



SECTION ON COL. (E)

0 2 4 6 8 10 12 14

SCALE 1:200

			SECTION General Layout	CLIENT CAUMET	TITRE - TITLE	NO LISTE BOM NO
			SCALE 1:200		30000 T.P.Y.	NO PROJET PROJECT NO
			DRAWN P.DESCHAMBAULT	LOCATION	ASBESTOS TAILINGS	1409
				KILBORN	DRY PROCESS MILL	NO DESSIN - DRAWING NO
					GENERAL LAYOUT	10-F-03
					SECTIONS	
						NO DIVISION DIVISION NO
						19
						REV
	DESCRIPTION	DATE	BY			
	REVISIONS					

KILBORN

CLIENT: CANMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING

AREA: DRY MILL

PROJ No. M096 | DIV. No. 15 | AREA No.

ESTIMATOR: PSK | CHECKED | EXTENSIONS | APPROVED

PROJECT ESTIMATE

TYPE: CLASS 2.0.1

SHEET No. 1 OF 5

ESTIMATE No.

DATE: FEB. 5, 85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
100	SITEWORK:												
	EXCAVATION		1550	M^3							$15.78/M^3$		24,459
	BACKFILL		1550	M^3							$19.50/M^3$		30,225
											TOTAL		54,684
200	BUILDINGS & STRUCTURES:												
	CONCRETE & EMB STEEL		1350	M^3							$900/M^3$		1,215,000
	STEEL		890	T							$3100/T$		2,759,000
	FLOORS ETC.		5310	M^2							$45/M^2$		238,950
	ROOFING ETC.		1200	M^2							$85/M^2$		102,000
	SIDING		6040	M^2							$255/M^2$		1,540,200
	DOORS ETC. (MISCELLANEOUS)												314,000
											TOTAL		5,969,150
300	BUILDING SERVICES:												
	ALLOWANCE												200,000
	TOTAL												

FORM 82 220 REV. 1

KILBORN

PROJECT ESTIMATE

CLIENT: CANMET | PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING | PROJ No: M096 | D.V. No: 15 | AREA: Dry Mill | AREA No: | ESTIMATOR: RC MAC/AK | CHECKED: | EXTENSIONS: | APPROVED: | TYPE: CMP COM | SHEET No: 2 OF 5 | ESTIMATE No: | DATE: 23/2 & 25/2 83

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE $/HR	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
400	MECHANICAL EQUIPMENT:												
	BELT CONVEYOR 36-inch (900mm) 96.6 Meters long - belting, idlers, pulleys, structure, drive - excl. motor		1			580	25	112500		44900			157400
	SCREEN, VIBRATING, 5 ft x 12 ft (1500 x 3600) double deck c/w drive, motor, sc. cloth and flopper.		1			100	25	12000		23000			35000
	BIN		1			150	25	11250		20000			31250
	BELT FEEDER (7M) c/w motor		1			50	25	3750		15000			18750
	DRYER, rotary - 2.4 m x 14.2 m long c/w trunnion, hot air furnace discharge manifold inc efficiency cyclone, baghouse, i/c ducting, fans, control electrics, excl. motor		1			3000	25	225000		1196000			1421000
	OIL STORAGE and supply system					250	25	18750		30000			48750
	DISTRIBUTOR - 4-way c/w drive excl. motors		1			100	25	7500		15000			22500
	SCREENS, GYRATORY, 5 ft x 10 ft (1500 x 3000) screening surface c/w unmounted decks, double surface, flat/disch. entries sleeves, screen cloth, access doors, eccentric drive - excl. motor		28		150	4200	25	315000	32230	902440			1217440
	FINERIZERS, TORREY - 2-stage vertical c/w liners, hammers, drive - excl. motors		4		170	680	25	51000	58500	234000			285000
	TOTAL							756750		2580340			3337090

FORM KE 226 REV. 1

KILBORN

PROJECT ESTIMATE

CLIENT: CANMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING

AREA: DRY MILL

PROJ No. M096 | DIV. No. 15 | AREA No.

TYPE: CONCOM

ESTIMATOR: RSM/MMC | CHECKED | EXTENSIONS | APPROVED

SHEET No. 3 OF 5 | ESTIMATE No. | DATE 29/2/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
900	MECHANICAL EQUIPMENT (CONT'D):												
	FILTER SYSTEM, c/w Jamesbury filter inserts, filter housings, manifolds, plenum chamber, pre-wired control panel, fire sensors, elect. motors - 180,000 cfm air capacity, c/w gathering conveyors		1		1200	2200	75	165000		725000			890000
	COLLECTOR, DRY CYCLONE, unlined, flanged for duct and air locks mounting - 7 feet (2100) diam.		8		80	640	75	48000	13500	108000			156000
	-DO ABOVE - 9 feet (2700) diam.		8		120	960	75	72000	16500	132000			204000
	AIRLOCK VALVES Rotary 20-inch I.D. (500 mm), flanged for mounting, c/w drives, excl. motors		16		incl.			-	6000	96000			96000
	DEDUSTERS Turgotals, 36 inch x 100 inch long (900 mm x 2500 mm), c/w removable mesh mounting panels, removable covers, revolving flanges, saddle mounted, drives, excl. motors		8		180	1440	75	108000	25000	200000			308000
	TURBOFANBLOWERS heavy duty, c/w driver excl. motors		9		170	1530	75	114750	14000	126000			240750
	RING JIBBING - 10 tonne capacity c/w heavy duty hoist motor, screw lights, brackets, chain drive, excl. motors		2		375	750	75	56250	65000	130000			186250
	TOTAL							560000		1522000			2091000

FORM KE 220 REV. 1

KILBORN

PROJECT ESTIMATE

CLIENT: CONNET
PROJECT: COMPREHENSIVE COST STUDY — WET & DRY MILLING
AREA: DRY MILL
PROJ No. N1946
DIV. No. 15
AREA No.
ESTIMATOR RSH/MH CHECKED
EXTENSIONS APPROVED
TYPE COMP 2004
SHEET No. 4 OF 5
ESTIMATE No.
DATE 29/8/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
400	MECHANICAL EQUIPMENT (CONT):												
	PRESSURE PACKING MACHINES, IT 50 kg. (?) PACKAGE, C/W individual hydraulic units piped fully for high pressure operation, pre-compression units, automatic weigh hopper and scale, package filters.		4		1200	4800	25.00	120000	296,000	1184000			1544120
	BELT CONVEYORS		12		250	3000	25.00	225000		325000			550000
	SCREW CONVEYORS		6		40	240	25.00	18000		52000			70000
	BUCKET ELEVATORS		3		80	240	25.00	18000		90000			108000
	MOTORS		1 LOT			INCL				288000			288000
	CHUTEWORK COMPLETE		1 LOT									225000	225000
	DUCT WORK (EXPLOSION COMPLETE)		1 LOT									125000	125000
	DUCT WORK (ENVIRONMENTAL		1 LOT									250000	250000
	LABORATORY EQUIPMENT		1 LOT					7180		592		1200000	1207592
						DTM (1)		821000		1949000		850000	3420000
						(1)		56+2000		132000			2091000
						(2)		756750		2580340			3337090
										1			1
	TOTAL							1941750		6056350		8500000	26481000

FORM OE 888 REV. 1

KILBORN

PROJECT ESTIMATE

CLIENT: CAMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING

AREA: DRY MILL

PROJ. No. 1496

DIV. No. 5

AREA No.

ESTIMATOR: AJG CHECKED: SHEET No. 5 OF 5

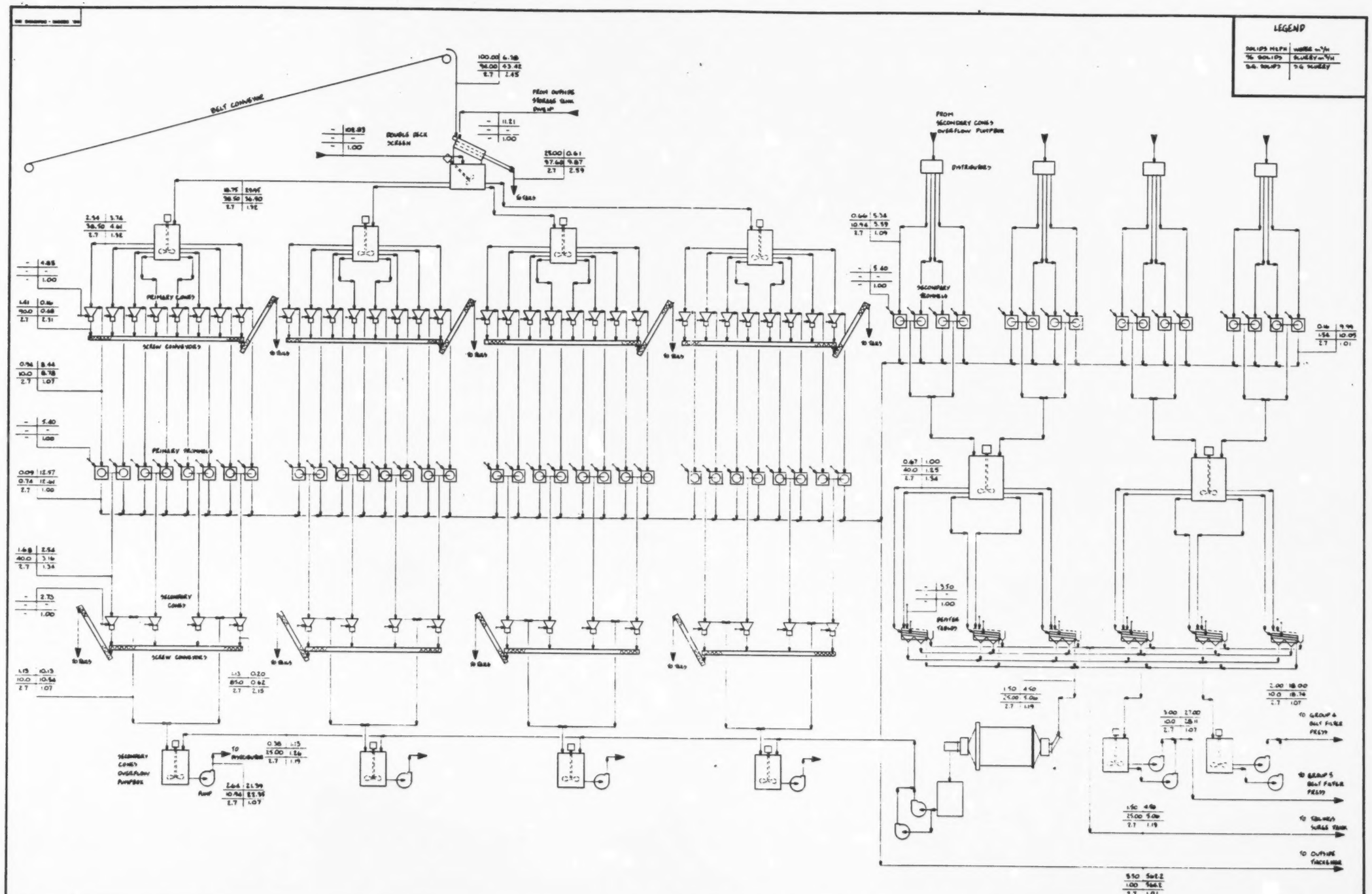
EXTENSIONS: APPROVED: ESTIMATE No.

TYPE: COMP COST

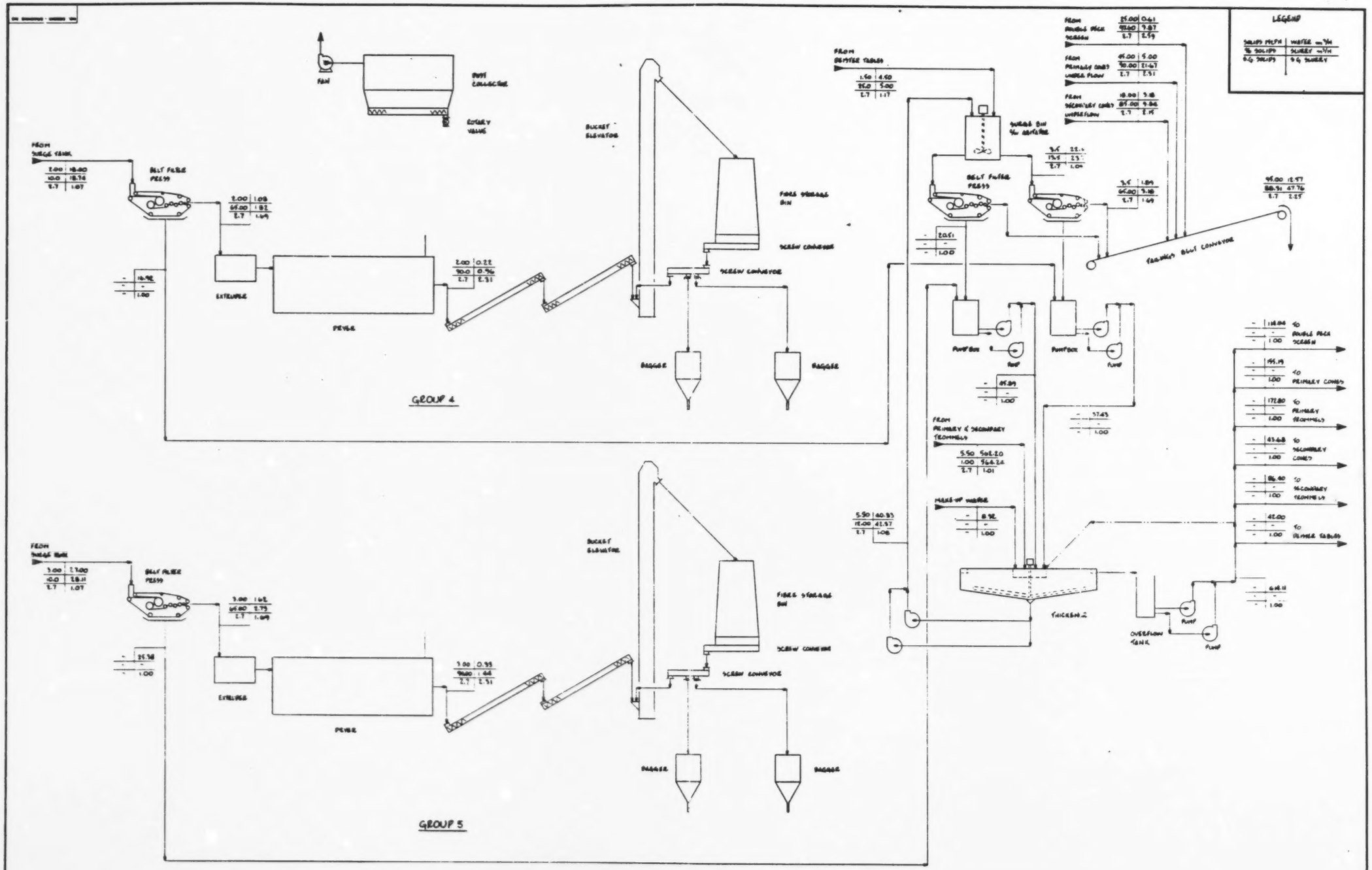
DATE: 29/8/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
500	PROCESS PIPING												
	(OTHER BUILDING)											25000	25000
600	ELECTRICAL											500000	500000
	TOTAL												

FORM KE 216 REV. 1


LEGEND
BELT CONVEYOR
DOUBLE DECK SCREEN
FROM OUTSIDE STOCKPILE
SCREEN CONVEYORS
PRIMARY CONES
PRIMARY FEEDWELLS
SECONDARY CONES
SECONDARY CONES OVERFLOW PUMPBOX
SECONDARY FEEDWELLS
FROM SECONDARY CONES OVERFLOW PUMPBOX
DISTRIBUTORS
PRIMARY FEEDWELLS
TO GROUP 4 BELT FILTER FEEDS
TO GROUP 5 BELT FILTER FEEDS
TO OUTSIDE THICKENER

| | | |



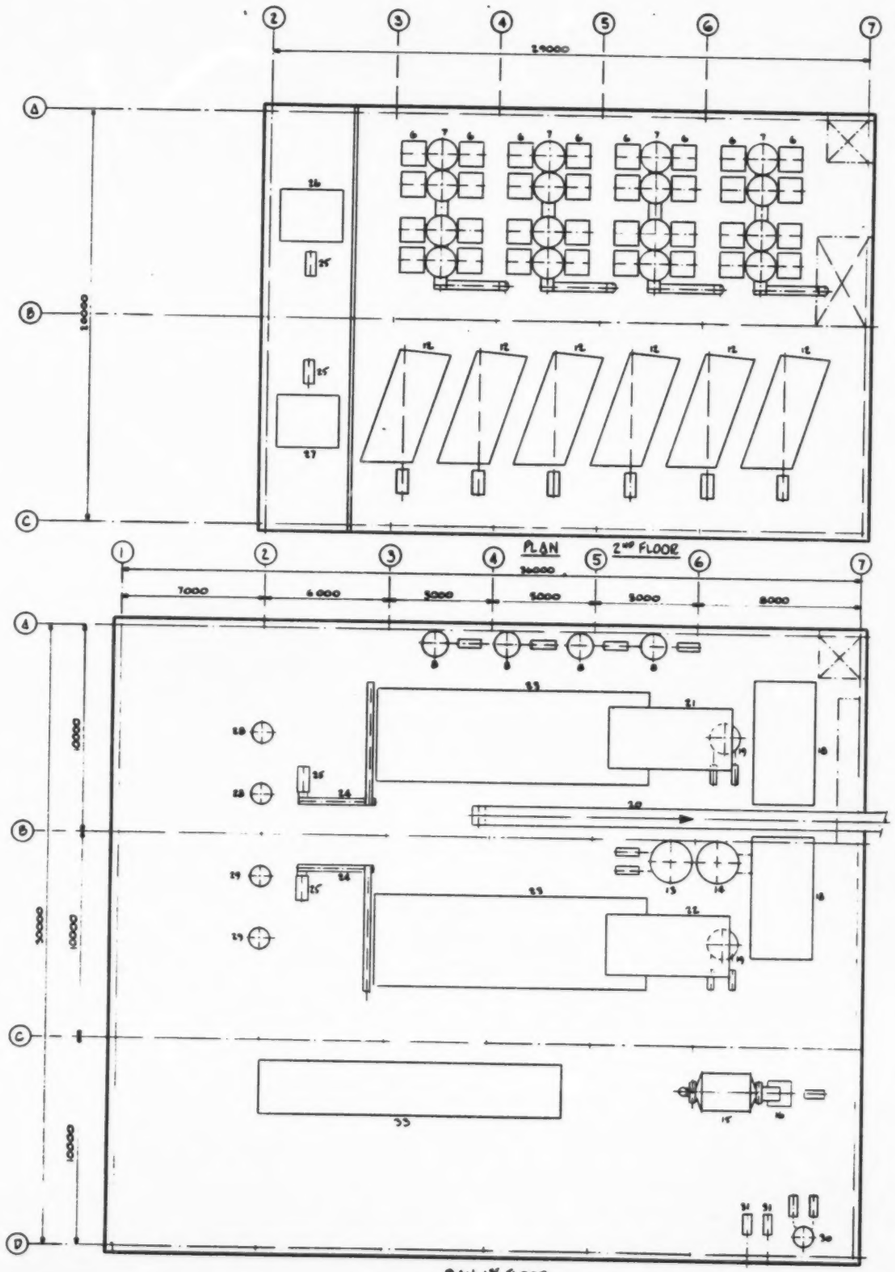
DESIGNED AS REFERENCE - REFERENCE DRAWINGS	DESCRIPTION	DESCRIPTION	DESCRIPTION	DESCRIPTION	
	REVISIONS	REVISIONS	REVISIONS	REVISIONS	

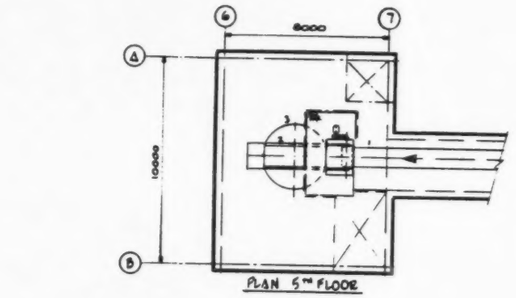
SECTION: GENERAL LAYOUT
PROVISIONAL

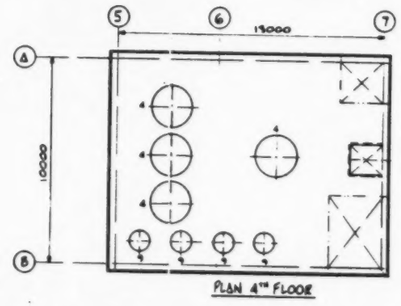
CLIENT: CANNEY
KILBORN

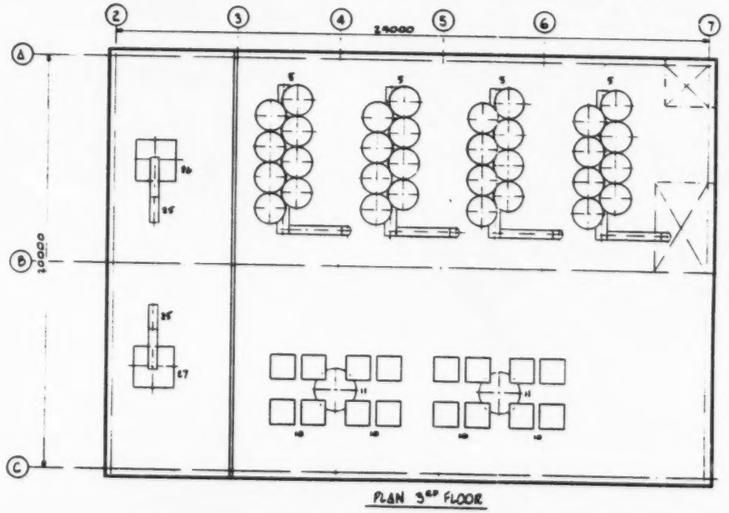
TITLE - TITLE
50 000 MTPY
GYPSUM (CEILING)
WET PROCESS
FLOWSHEET

NO. DRAWING NO.
MON 15
10-F-05









LEGEND

1. BELT CONVEYOR (MAIN FEED)
2. DOUBLE DECK SCREEN
3. DISTRIBUTOR C/W AGITATOR
4. DISTRIBUTOR C/W AGITATOR
5. PRIMARY CONES C/W SCREW CONVEYORS
6. PRIMARY TROMMELS
7. SECONDARY TROMMELS C/W SCREW CONVEYORS
8. SECONDARY CONES OVERFLOW PUMPBOX C/W AGITATOR
9. DISTRIBUTOR
10. SECONDARY TROMMELS
11. TABLE FEED DISTRIBUTOR C/W AGITATOR
12. DEISTER TABLE
13. FILTER FEED TANK GROUP 4
14. FILTER FEED TANK GROUP 5
15. ROD MILL
16. PUMPBOX
17. SURGE BIN C/W AGITATOR
18. BELT FILTER PRESS (TAILINGS)
19. PUMPBOX
20. TAILINGS BELT CONVEYOR
21. BELT FILTER PRESS GROUP 4
22. BELT FILTER PRESS GROUP 5
23. EXTRUDER & DRYER
24. SCREW CONVEYOR
25. BUCKET ELEVATOR
26. FIBRE STORAGE BIN GROUP 4
27. FIBRE STORAGE BIN GROUP 5
28. BAGGER GROUP 4
29. BAGGER GROUP 5
30. THICKENER OVERFLOW TANK
31. THICKENER UNDERFLOW PUMPS
32. THICKENER HOT WATER
33. DUST COLLECTOR

SCALE 1:100

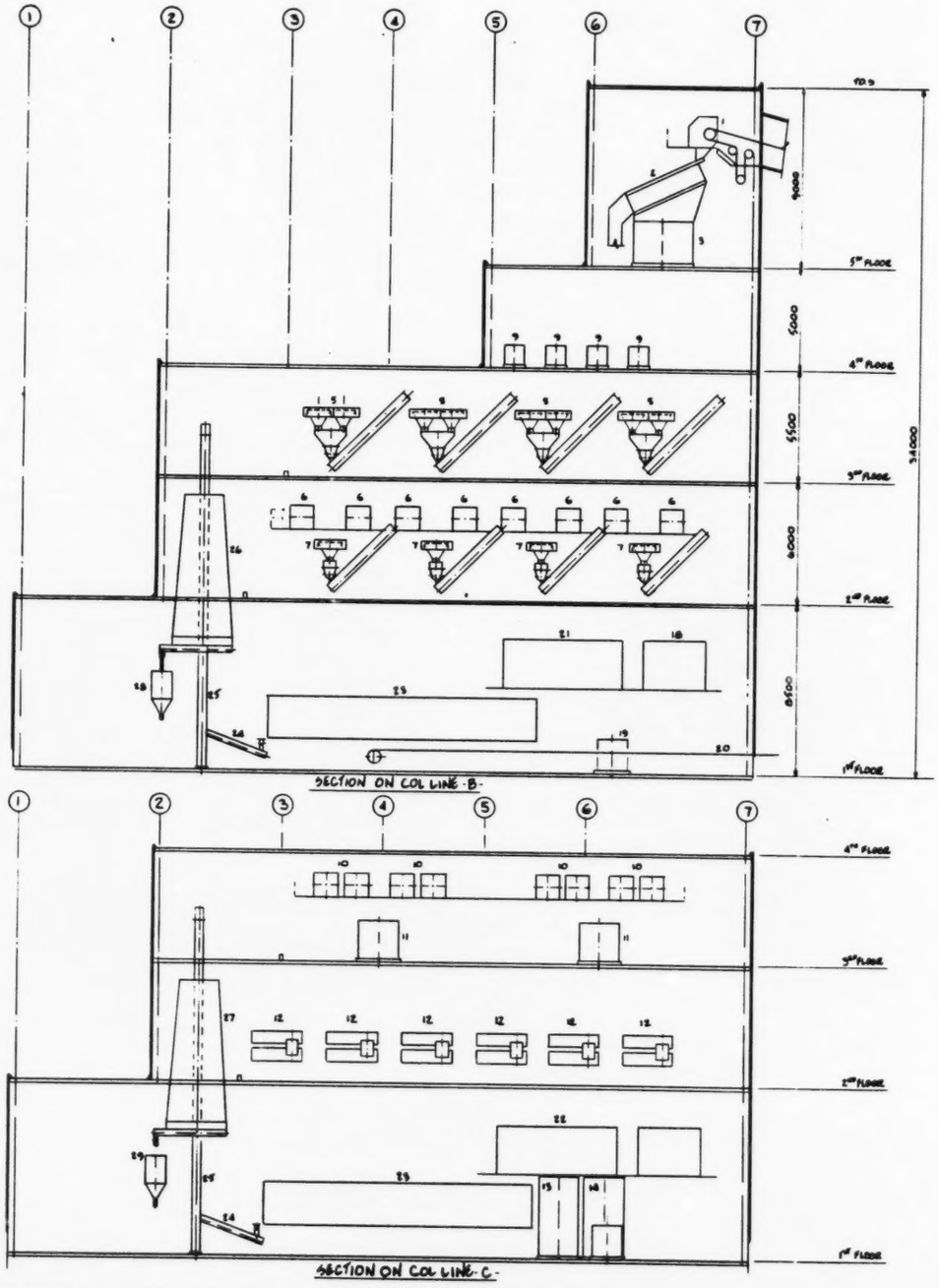
CODING OF REFERENCE - REFERENCE DRAWINGS

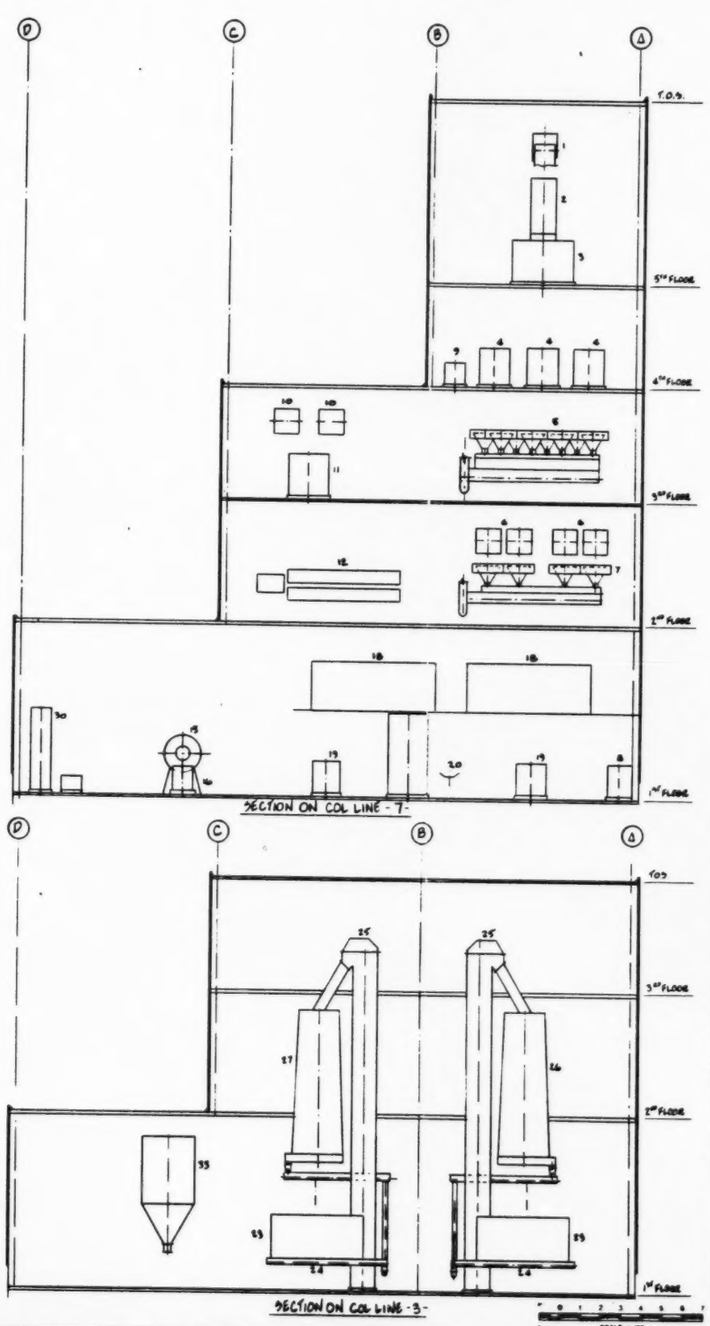
REVISIONS

SECTION: GENERAL LAYOUT
SCALE: 1:100
DRAWN: D BOYSEN
CLIENT: CANMET
ENERGY LOCATION:
KILBORN

TITLE: 30,000 MTPY ASBESTOS TAILINGS WET PROCESS MILL GENERAL LAYOUT PLANS

NO. JOB: M096
NO. PROJECT: 15
NO. DRAWING: 10-F-06





LEGEND

1. BELT CONVEYOR (MAIN FEED)
2. DOUBLE DECK SCREEN
3. DISTRIBUTOR C/W AGITATOR
4. DISTRIBUTOR C/W AGITATOR
5. PRIMARY CONES C/W SCREW CONVEYORS
6. PRIMARY TROMMELS
7. SECONDARY TROMMELS C/W SCREW CONVEYORS
8. SECONDARY CONES OVERFLOW PUMPBOX C/W AGITATOR
9. DISTRIBUTOR
10. SECONDARY TROMMELS
11. TABLE FEED DISTRIBUTOR C/W AGITATOR
12. DEESTER TABLE
13. FILTER FEED TANK GROUP 4
14. FILTER FEED TANK GROUP 5
15. ROD MILL
16. PUMPBOX
17. SURGE BIN C/W AGITATOR
18. BELT FILTER PRESS (TAILINGS)
19. PUMPBOX
20. TAILINGS BELT CONVEYOR
21. BELT FILTER PRESS GROUP 4
22. BELT FILTER PRESS GROUP 5
23. EXTRUDER & HOPPER
24. SCREW CONVEYOR
25. BUCKET ELEVATOR
26. FIBRE STORAGE BIN GROUP 4
27. FIBRE STORAGE BIN GROUP 5
28. BAGGER GROUP 4
29. BAGGER GROUP 5
30. THICKENER OVERFLOW TANK
31. THICKENER UNDERFLOW PUMPS
32. THICKENER HOT SHEDD
33. DUST COLLECTOR

SCALE 1:100

DESIGNS OF REFERENCE - REFERENCE DRAWINGS

REVISIONS

SECTION	GENERAL LAYOUT
SCALE	1:100
DRAWN	D BOYSEN 10/85
CLIENT	CANNET
LOCATION	
TITLE	30,000 MTPY ASBESTOS TAILINGS WET PROCESS MILL GENERAL LAYOUT SECTIONS
JOB NO	MO96
DIVISION NO	15
DRAWING NO	10-F-07

KILBORN

KILBORN

CLIENT: CONMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING

AREA: WET MILL

PROJ. No. 4056

DIV. No.

AREA No.

ESTIMATOR: KSK CHECKED SHEET No. 1 OF

EXTENSIONS APPROVED ESTIMATE No.

DATE

PROJECT ESTIMATE

TYPE: COMPOSITE

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
100	SITE WORK:												
	EXCAVATION (INCL THICKENER)		900	M^3							$15.75/m^3$		14,250
	BACKFILL (INCL THICKENER)		900	M^3							$13.50/m^3$		12,150
													31,800
200	BUILDING & STRUCTURES												
	CONCRETE & EMB. STEEL (INCL THICKENER)		710	M^3							$900/m^3$		963,900
	STEEL (INCL THICKENER)		365	T							$2100/T$		1,131,500
	FLOORS ETC.		5200	M^2							$45/m^2$		234,000
	ROOFING ETC		1080	M^2							$85/m^2$		91,800
	SIDING		2820	M^2							$85/m^2$		239,700
	DOORS ETC (ALLOWANCE)												230,000
													2,560,000
300	BUILDING SERVICES:												
	ALLOWANCE												200,000
	TOTAL												

FORM KE 220 REV. 1

KILBORN

CLIENT: CANMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING

AREA: WET MILL

PROJ No. 1096

DIV No. 05

AREA No.

ESTIMATOR: AVG CHECKED

EXTENSIONS APPROVED

PROJECT ESTIMATE

TYPE: COMP COST

SHEET No. 2 OF

ESTIMATE No.

DATE: 3/12/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
400	MECHANICAL EQUIPMENT:												
	BELT CONVEYOR (36") 900mm 20 m (45°) c/w BELTING, IDLERS, PULLEYS, ENCLOSED, ETC		1			350	75.00	26250		34000			60250
	TAILING RECEIVING BIN (3.6m Ø x 3.6 H) 12 Ø x 12'		1			150	75.00	11250		20000			31250
	BELT FEEDER (7m) c/w MOTOR		1			50	75.00	3750		15000			18750
	HIGH FLOW CONVEYOR (16") 900mm 100 m (+15°) c/w BELTING, IDLERS, PULLEYS, ENCLOSED, ETC		1			1600	75.00	120000		150000			270000
	SCREEN - VIBRATING, 5 ft x 12 ft (1500x3600) double deck, c/w drive, 5HP motor screen cloth and hopper		1			160	75.00	12000		23000			35000
	DISTRIBUTOR NO 1 - 3m Ø x 2m = 14 m³ CAP (INCL. AGITATOR 5HP)		1		85	85	75.00	6375	16500	16500			22875
	DISTRIBUTORS NO 2 - 5 1.5m Ø x 1.8m : 3m³ CAP (INCL. AGITATOR 5HP)		4		55	220	75.00	16500	13500	54000			70500
	PRIMARY CONES 1-32 1.2 m Ø x 1.7 m (4' Ø x 4') WITH DISCHARGE BOX AND INFLOW LAUNDERS		32		30	960	75.00	72000	3500	112000			184000
	DISCHARGE SCREWS - 6 TONNES/HOUR - 356 mm (14" Ø) 10 RPM 5HP MOTOR 6 METRE		4		40	160	75.00	12000	13000	72000			84000
	ANGLED DISCHARGE SCREWS 356 mm + 80°) 7.5 TPH RADIAL - 3.5 M		4		40	160	75.00	12000	10500	42000			54000
	TOTAL							242125		530500			930625

FORM KE 220 REV. 1

KILBORN

CLIENT: CANMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING — PROJ. No. 4296

AREA: WET MILL — DIV. No. 15 — AREA No.

ESTIMATOR: AVG — CHECKED — EXTENSIONS — APPROVED

PROJECT ESTIMATE TYPE: SUMP 000 m

SHEET No. 3 OF — ESTIMATE No. — DATE: 5/2/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
450	MECHANICAL EQUIPMENT (CONT):												
	PRIMARY WASHING TROMMEL 0.9m Ø x 1.2m (3'6" x 4') C/W 5HP MOTOR		32		30	960	75.00	72000	15000	480000			552000
	SECONDARY CONES (33-48) 1.2m Ø x 1.2m 4'Ø x 4' WITH DISCHARGE BOX AND OVERFLOW LAUNDER		16		30	480	75.00	36000	35000	560000			920000
	DISCHARGE SCREW TONNES/HR 356 mm Ø (14" Ø) 10 RPM, 5HP MOTOR GM		4		40	160	75.00	12000	18000	72000			84000
	ANGLED DISCHARGE SCREW 356mm Ø (14" Ø) +30° L 10 RPM 7.5 HP MOTOR 3.1m		4		40	160	75.00	12000	10500	42000			54000
	PUMPBOX 1-4 CAP 3 m³ 1.2m Ø x 1.5m		4		20	80	75.00	6000	3000	12000			18000
	PUMPS 1-4 3X3 SRL 1600 RPM 10 HP		4		20	80	75.00	6000	4500	18000			24000
	DISTRIBUTORS No. 6-9 1½ m Ø x 1m 1.8 m³ CAP.		4		20	80	75.00	6000	3000	12000			18000
	SECONDARY WASHING TROMMEL 0.6m Ø x 1.2m (2'Ø x 4') C/W 5HP MOTOR		16		30	480	75.00	36000	15000	240000			276000
	DISTRIBUTORS - No 10 + 11 - 2m Ø x 2m - 5m³ CAP INCL AGITATORS 5HP)		2		65	130	75.00	9750	15000	30000			39750
	DENVER - CONNECO "D8" TWIN DECK THICKENER 3HP MOTOR 1200 RPM		6		150	900	75.00	67500	44100	264000			331500
	TOTAL							263250		1226600			1489850

FORM KE 266 REV. 1

KILBORN

CLIENT: CANMET

PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING

AREA: WET MILL

PROJ No. KW 96

DIV. No. 15

AREA No.

ESTIMATOR: J.H.K. CHECKED: APPROVED: EXTENSIONS:

PROJECT ESTIMATE TYPE: COMP OOH

SHEET No. 4 OF

ESTIMATE No.

DATE: 3/9/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
400	MECHANICAL EQUIPMENT (CONT):												
	FEED TANKS (PRODUCT TO FILTERS) 2.5M Ø X 2.5M (INCL AGITATOR 5HP)		2		30	160	75.00	12000	16500	33000			45000
	FEED TANK PUMPS 3X3 SRL 3HP		4		20	80	75.00	12000	3500	14000			26000
	ROD MILL 1200 Ø X 1800 (4' Ø X 6') SRR-TYPE (SALA RUBBER ROLLER TYPE) 50 HP		1		200	200	75.00	15000	73000	73000			88000
	DISCHARGE PUMP FOR 1M Ø X 1M (1M³ CAP)		1		20	20	75.00	1500		2500			4000
	DISCHARGE PUMP 3X3 SRL 1200 RPM 3 HP		2		20	40	75.00	6000	3500	7000			13000
	KOMLINE-SANDERSON BELT FILTER PRESSES HIGH PRESSURE "NIP" ROLL TYPE (FEED MOISTURE REDUCTION TO 65% SOLIDS)		4		300	1200	75.00	90000	250,000	1000000			1090000
	DISTRIBUTOR 1.5M Ø X 1.8M (CAP 3M³) (INCL AGITATOR 5HP)		1		55	55	75.00	4125	13500	13500			17625
	FILTRATE RECEIVING TANK 1.5M Ø X 1.5M		2		55	110	75.00	8250	3000	6000			14250
	FILTRATE DISCHARGE PUMP 5X4 SRL 1100 RPM 10HP		2		40	80	75.00	6000	4500	9000			15000
	FILTRATE DISCHARGE PUMP 5X4 SRL 1100 RPM 15HP		2		40	80	75.00	6000	6000	12000			18000
	THICKENER 25M Ø X 4M (82' Ø X 12.5') STRUCTURE (INCL IN CONCRETE) - MECHANISM		1		600	800	75.00	60000		125000			185000
	TOTAL							220825		1295000			1515825

FORM KE 226 REV. 1

KILBORN

PROJECT ESTIMATE

CLIENT: CANMET
PROJECT: COMPARATIVE COST STUDY — WET & DRY MILLING
AREA: WET MILL
PROJ No. 4096
DIV. No. 15
AREA No.
ESTIMATOR: MBL
CHECKED
EXTENSIONS
APPROVED
TYPE: CLASS 'C'
SHEET No. 5 OF
ESTIMATE No.
DATE: 3/9/85

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
4000	MECHANICAL EQUIPMENT (CONT):												
	THICKENER OVER FLOW TANK (PONY TANK)												
	1M Ø x 4M		1		—	—	—			5200			5200
	OVER FLOW DISCHARGE PUMP 8X10X13 (WARMAN) 75HP		2		25	50	75	3750	5300	10600			14350
	THICKENER UNDER FLOW PUMP 3X3SRL (GOULDS) 3HP		2		20	40	75	6000	350	700			12700
	EXTRUDER - DRYER BELTYPE SIXTY METRES												
	PROCTOR - SCHWARTZ		2		450	900	75	67500	250000	500000			567500
	ELECTRIC STEAM BOILER CHROMALOX												
	MODEL KCMS 150 PSI — 10,000 lbs steam/hr												
	3200 KW (4200 HP)		1		250	250	75	18750	1200000	1200000			1218750
	SCREW CONVEYORS (5HP) 13 M EACH		4		25	100	75	7500	6000	24000			31500
	BUCKET ELEVATOR (17 METRES)		2		80	160	75	12000	30000	60000			72000
	FINE BIN		2		375	750	75	56250	80000	160000			216250
	BAGGING MACHINES		4		150	600	75	45000	50000	200000			245000
	TAILINGS CONVEYORS (INSIDE BUILDING)		1		40	400	75	30000		42500			72500
	75 M												
	1000 CFM DUST COLLECTION SYSTEMS		3		100	300	75	22500	30000	90000			112500
							75 M	2925000		11109000			14034000
							2	262500		5355000			5617500
							3	216375		1226600			1442975
							4	220875		1275000			1495875
	TOTAL							12755000		42559200			53047200

FORM DE 816 REV. 1

KILBORN

PROJECT COMPARATIVE COST STUDY — WET & DRY MILLING — PROJ No. 4096
CLIENT: CANMET — DIV. No. 15 — ESTIMATOR A.L. — CHECKED — SHEET No. 6 OF
AREA WET MILL — AREA No. — EXTENSIONS — APPROVED — ESTIMATE No.
PROJECT ESTIMATE — TYPE COMP COST — DATE

ACCOUNT CODE	DESCRIPTION	TYPE	QUANTITY	UNIT	LABOUR UNIT MH	LABOUR TOTAL MH	LABOUR RATE MH	LABOUR COST	MATERIAL UNIT COST	MATERIAL COST	SUB-CONTRACT UNIT COST	SUB-CONTRACT COST	TOTAL COST
500	PROCESS PIPING :												
	ALLOWANCE (48% EQUIPMENT)												765 00
600	ELECTRICAL :												
	ALLOWANCE (12% OF OTHER EQUIPMENT)												460 00
	TOTAL												

FORM KE 226 REV. 1